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Identification of Paddy Leaves Disease using Convolutional Neural Networks

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Abstract: The economic development of any country mainly depends on agriculture. Rice is a staple crop and a significant food source for a large portion of the world's population and rice usage is higher in Asia. But, the rice crop suffers from various diseases that greatly affect yield capacity and have an impact on food security. For the effective disease management and crop detection, the disease need to be detected early and diagnosis to be done at the earliest. By automating the disease detection process, the system can enable early intervention and timely management practices, leading to improved crop yield and reduced economic losses. The proposed system effectively identifies paddy leaf disease, in which a median filter is used to reduce the noise, a Fuzzy C-Means (FCM) algorithm were used for segmentation, and a Convolutional Neural Network (CNN) were uses for classification. Contrast, homogeneity, energy, entropy, and correlation features are extracted from the segmented image for training and testing the CNN classifier. The proposed system effectively detects Brown Spots (BS), Leaf Blasts (LB), and Bacterial Blight (BLB) disease. The proposed system was implemented by using MATLAB (R2021a) software and tested with the help of three data sets with respect to performance parameters: sensitivity, specificity, accuracy, and precision. The maximum achieved accuracy of the proposed system is 98.68%.

Keywords: CNN, FCM, Brown Spots (BS), Leaf Blasts (LB), and Bacterial Blight (BLB).

1. Introduction

The economic development of any country is greatly affected by the agricultural sector. The majority of countries are dependent on agricultural goods in terms of raw materials. In the most of the countries in the world rice is cultivated and it is cultivated approximately in the 100 countries. The worlds' population is growing day by day and will tend to increase at the higher rates in the near future and present population is around 8.12 billion. The higher food will be consumed by growing population which leads demand and need more supply.

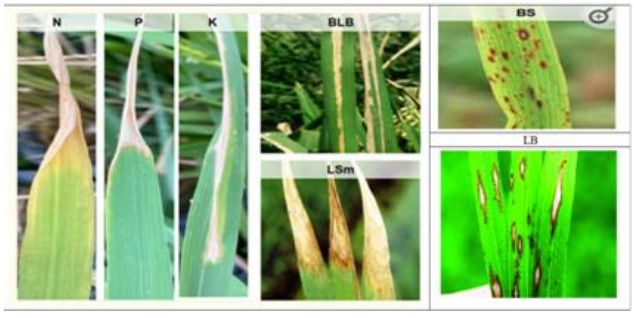

Figure. 1 Types of diseases and nutrient deficiencies in rice plants.

The world's largest continent is Asia, which produces rice heavily and whose usage is also very high. Rice is cultivated on around 164.5 million hectares in the world at present. Rice yields need to increase in the world as population grows day by day. In this way, the rate of growth the rice yield and production must be sustained over the subsequent decades so that poverty, hunger, undernourishment, food security etc., so that do not reach critical point of failure. However, growth of rice plants and yields will be affected by diseases and nutrient deficiency disorders. Fungi, bacteria, viruses, and a lack of nutrients affect the numerous catastrophic rice plants. Different types of common diseases and nutrient deficiencies in the rice plant are shown in the figure 1.

In the world, fifty percent of yield losses are caused by the Bacterial Leaf Blast (BLB) alone. Diseases like Brown Spots, Leaf Smut(LSm), and Leaf Blast (LB) are also affects the rice yield significantly. Brown Spots are the common rice diseases caused by Drechsleraoryzae. BS lesions are often curved, brown in color, and surrounded by a yellow rim. These BS affected ninety percent of the rice crop yield in the Bengal Famine during the 1940s. In Asia, rice crop yield reductions between 6 to 90% by the affect of Leaf Smut(LSm) which is cuased by

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Entylomaoryzae. These diseases cause small, darkened patches on the undersides of the leaves and do not affect the rice crop yield significantly, so they are considered minor diseases. But LSm accelerates the drying of the leaves permaturely, so that this disease cannot be ignored.

In addition to rice plant diseases, it suffers from deficiencies of macro- or micronutrients like nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), and Magnesium (Mg). NPK levels will affect the rice crop yield more and be investigated more. Stunt root growth, drought, restricts photosynthesis caused by lack of P and K and makes the plants more susceptible to diseases. Protein and chlophyll content of rice is cuased by N deficiency and reduce the growth of crops.

Furthermore, it is now simpler to acces and analyze data on these specific contaminations. This is because there is already a lot of data on these common contaminations found in the rice crops. This study, therefore,provides detection of three common diseases Bacterial Leaf Blast (BLB), Brown Spots (BS), and Leaf Blast (LB) found in rice plants. Rice crop productivity can be increased, and crop loss can be reduced, by early detecting or identifying diseases.

2. Related Works

Petchiammal A *et al.* [1] have proposed PaddyNet model to detect the paddy leaf detection with enhanced accuracy of the leaf disease detection. The proposed PaddyNet contains 17 layers, captures and models patterns of different disease symptoms present in the paddy leaf images. The classifier trained by applying the large dataset contains 16,225 disease images across 13 classes, including a normal class and 12 disease classes. Here issues regarding to real time implementation were not considered.

Ch. Balaswamy *et al.* [2] provided an automated approach by using Support Vector Machine (SVM) for detecting three types of leaf diseases like Brown Spot (BS), Leaf Blast (LB), and Bacterial Blight (BLB). In this implemented method, the support vector machine classifier was trained by using training set and tested by using testing set which contained all kinds of diseases images. They developed an automated algorithm which will suggest the type of fertilizers/pesticides and to be used based on the detected severity of the disease.

Abisha R *et al.* [3] proposed system uses pre-processing and augmentation to extend the dataset, pre-trained Inception_v3 and deep learning based CNN algorithm to predict the paddy leaf diseases and these algorithm produces good accuracy rate and take less time to classifying the diseases. Training and testing accuracy of various classifiers are low.

P. Prasanth *et al.* [4] were used machine learning technique to detect the leaf diseases in the early stage. The implemented machine learning approach used the image augmentation techniques followed by machine learning algorithms. The support vector machine, k-nearest neighboring, decision tree, naïve bayes and random forest machine learning algorithms were employed. But accuracy of the classifiers were low.

Jyoti Dinkar Bhosale *et al.* [5] detected the rice paddy leaf diseases by using Probabilistic Neural Network (PNN), Evolutionary Technique and K-Nearest Neighbor classification methods. The reliability of an output relies on the input data when used in a number of agricultural research applications. A large collection of ill rice photographs were not used.

B. Sowmiya *et al.* [6] have used the computer vision technologies for early detection of paddy leaf diseases. The proposed method implemented in the real time applications to identify the diseases with more sensitivity, specificity and accuracy.

Pushpa Athisaya Sakila Rani and N. Suresh Singh [7] have identified or detected five types of paddy leaf diseases such as Bacterial Leaf Blast (BLB), Brown Spot (BS), Leaf Smut (LS), and Tungro. The researchers have used Convolutional Neural Network classification technique along with pre-processing and segmentation algorithm. They also used pre-trained ResNet-50 model to enhance the performance of the classifier. Sensitivity, specificity and accuracy were used to validate the performance of the classifier.

A. F. A. Ahmad Effendi *et al.* [8] have used K-Means clustering algorithm for segmenting the image for detecting the diseases or affected area and color conversion & image scaling was used in the pre-processing stage. The Gray Level Co-occurrence Matrix (GLCM) was used to extract the statistical features from the segmented image. The proposed method was implemented in the MATLAB software and PC hardware to process infected paddy leaf images. The results of the proposed system have shown the better performance in detecting the paddy leaf disease.

N. Vidya Sagar and P. Venkata Siva [9] they used artificial intelligence strategies to investigate the diagnosis the type of infection which was influenced the yield depends on the harvests picture information and also it gave as late introduced methods their presentation measure. A portion of the huge illnesses influencing the O. Sativa crop are itemized as follows: A parasitic illness that contaminates the whole yield that can be handily

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distinguished in the beginning phases as it shows up on the underlying seedling leaves like earthy colored oval or round spots.

Arun vijakumar.B, Girija.G, and Harini.S [10] mainly detected and classified three types of paddy leaves diseases namely Brown Spots (BS), Hispa and Leaf Blast (LB) with help of Convolutional Neural Network (CNN). The CNN classifier is took the input image and allotted values to the variousaspects which are present in the image and differentiated with one another. AlexNet were employed to train and test the sample images of healthy or normal and diseased paddy crop. The implemented method achieved 97% and compared with existing method.

Nilam Sachin Patil, and E. Kannan [11] have pre-processed both healthy and disease using pre-processing techniques, well defined algorithms or feature extracting techniques were used to extract the features. The extracted features were applied for training and testing the classifier to identify the paddy leaf diseases. The cascaded network was employed to explore or detect the diseases of the paddy leaves. Genetic with nearest neighbor algorithm was also used to detect the paddy leaves diseases and results were compared with the existing method.

B. Dhivya *et al.* [12] detected diseases for crops like paddy, plants like brinjal and tress. Grayscale conversion is done for the pre- processing and noises removed by using median filter algorithm. For the leaf segmentation Active Contour approach is implemented. For the classification part, Multilayer Convolutional Neural Network (MCNN) is implemented.

V. Vanitha [13] has used deep learning Convolutional Neural Network (CNN) classifier to detect or predict rice plant diseases automatically. The researcher has used the data set which consisting of 500 images such that contains both normal or healthy and diseased images and CNN classifier trained and tested to detect of predict three type of diseases. She has experimented with help of Convolutional Neural Network to improve the accuracy for identification of rice diseases and effectively detected.

R. Sahith *et al.* [14] have focused mainly on machine learning techniques to detect or find the rice paddy diseases (RPD). The researchers have collected the large number of infected rice palnts data from the UCI machine learning repository. They have conducted experiments with help of decision tree-based machine learning algorithms such as random forest, REPTree and J48. They have used color layout filter supported by WEKA for extracting the numerical features from both normal and infected images. Classifiers based on machine learning techniques like fuzzy-type, neural network type and bio-inspired type techniques are considered to improve the detection accuracy of the classifier.

3. Theory and Calculation

The primary objectives of this research includes the development and implementation of a Convolutional Neural Network (CNN) based system for identifying paddy leaves disease by utilizing freely available images in the website. Our methodology involves the extraction of pertinent features from diverse datasets, encompassing paddy leaves disease, diagnostic assessments, and imaging modalities. The CNN model is trained to classify different severity levels of paddy leaves disease and predict the progression of the disease. Feature selection and model optimization techniques are employed to enhance the CNNs' performance, ensuring its robustness and accuracy.

The Features such as contrast, energy, entropy, homogeneity and correlation which are used to capture textural patterns indicative of osteoarthritis severity. The Features of Region of Interest (ROI) are computed by using Grey-Level Co-occurrence Matrix (GLCM) in the MATLAB. Texture features are extracted using Grey Level Co-occurrence Matrix and the GLCM function characterizes the texture of an image by calculating how often pairs of the pixels with specific values and in a specified spatial relation occur in an image.

Contrast: It is measure of the intensity contrast between two pixels and it is calculated by using equation (1)

$$\alpha_c = \sum_{i,j}(|i-j|^2)x(i,j) \quad (1)$$

Energy: It is measure of the sum of the squared elements and it is calculated by using the equation (2)

$$\alpha_E = \sum_{i,j}(x_{ij})^2 \quad (2)$$

Homogeneity: It is measure of the closeness and distribution between the pixels and it is calculated by using equation (3)

$$\alpha_H = \sum_{i,j}\frac{x(i,j)}{1+|i-j|} \quad (3)$$

Correlation: It measures the similarities between the pixels and it is calculated by using the equation (4)

$$\alpha_{CR} = \sum_{i,j}\frac{(i-m_{1i})(j-m_{1j})x_{ij}}{\sigma_i\sigma_j} \quad (4)$$

Entropy: Measure the randomness of intensity levels and it is calculated using equation (5)

$$\alpha_{Et} = \sum_{i,j} x_{ij}\ log_2(\frac{1}{x_{ij}}) \quad (5)$$

The performance identification of the classifier is computed with help of a 2x2 contingency table as shown in the table 1.

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Table. 1 Contingency table with 2x2 for the presence and absence of the paddy leaves diseases

Classifier output	Actual input		Total
	Present	Absent	
Present	True Positive	False Positive	All test Positive
Absent	False Negative	True Negative	All test Negative
Total	Total Actual Presences	Total Actual Absences	Total

True Positive (TP) which represents hits, **True Negative (TN)** which represents number of correct rejections, **False Positive (FP)** which specifies number of false alarm, and

False Negative (FN) which specifies the number of misses of the classifier and these are used to measure the performance of the classifier.

True Positive (TP) = the classifiers' output which is positive in the presence of positive input and it is correct identification or detection.

True Negative (TN) = the classifiers' output which is negative in the presence of the positive input and it is correct rejection.

False Positive (FP) = the classifiers' output which is positive in the absence of the positive input and it is incorrect identification or detection.

False Negative (FN) = the classifiers' output which is negative in the presence of positive input and it is incorrect rejection.

Based on the above four outputs, the following performance evaluation of classifier is evaluated.

Sensitivity: The ability of the classifier which measures the number positives which are correctly identified. The sensitivity is also called true positive rate or recall. The Sensitivity can be measured by using the equation (6).

$$\text{Sensitivity } \lambda_{SEN} = \frac{TP}{TP+FN} \quad (6)$$

Specificity: The ability of the classifier which measures the number of negatives which are correctly identified. The specificity is also called true negative rate of the classifier. The specificity can be measured by using the equation (7).

$$\text{Specificity } \lambda_{SPE} = \frac{TN}{TN+FP} \quad (7)$$

Accuracy: Correct recognition of the classifier is called 'accuracy'. It is measured using equation (8).

$$\text{Accuracy } \lambda_{ACC} = \frac{TP+TN}{TP+TN+FP+FN} \quad (8)$$

Precision: Precision of a classifier is the probability of positive outcome given that a positive classification results and contrast to the sensitivity of the classifier. This is called Positive Prediction Rate. The formula for PPV is given in equation (9)

$$\text{Precision } \lambda_{PPV} = \frac{TP}{(TP+FP)} \quad (9)$$

4. Experimental Method

The proposed methodology consists of 7 major blocks: Input Images, Preprocessing, FCM Segmentation, Features extraction, Classification and Validation as shown in the figure 2:

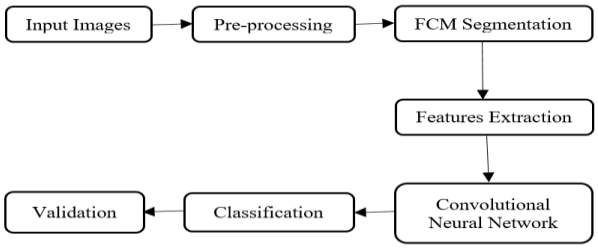

Figure. 2 Block diagram of the proposed method.

Input Images: Data set consists of both train set and test set which are used to train and test the CNN classifier respectively. Train set is used to train the classifier whereas test set is used o test the performance of the CNN classifier. Data set is created by down loading website which are freely available. The training set contains 54 normal images, 36 brown spot decease images, 29 leaf blast decease images and 33 bacterial blight decease. Testing set contains three data sets such that Test data set 1 contains 41 normal images & 37 brown spot images, Test data set 2 contains 41 normal images & 35 leaf blast images and Test data set 3 contains 41 normal images & 33 bacterial blight disease images.

Pre-processing: It is image enhancement technique which improves the appearance of the image by reducing the noise. In the first stage, image resizing is done, in which any size of the image is converted to 256x256. In the second stage, the Median filter is used in this proposed method in the pre-processing. The median filter plays very important role in the image processing as it is well known for the presentation of edges during noise removal.

The median filtering is belongs to nonlinear type which can be reduce the noise from images. The median filter works based on replacing the each pixel value by replacing the median values of the neighbouring pixels.

FCM Segmentation: Fuzzy C-Means segmentation algorithm is unsupervised image segmentation and does not take in to consideration the local information in the image context. It combines both region

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and edge features of the image and then merge regions recursively as per the criterion of the maximum fuzzy integral [15]. The following steps are used in the FCM Segmentation.

Step-1: Randomly choose at least two centroids and assign the values.
Step-2: Calculate membership matrix.
Step-3: Calculate the clusters C^k and $C^{(k-1)}$.
Step-4: If $C^{(k-1)} - C^k < \varepsilon$ then stop else go to step2.

Features Extraction: The statistical features such as contrast, energy, homogeneity, correlation and entropy are extracted from the segmented image to train and test the performance the classifier.

Convolutional Neural Network (CNN): A CNN has three layers which are convolution layer, pooling layer and fully connected layer as shown in the figure 3:

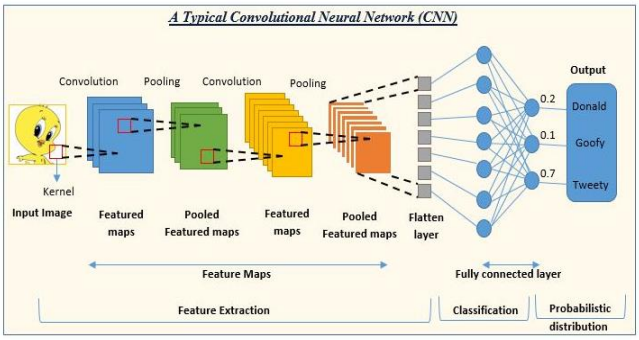

Figure. 3 Convolutional Neural Network (CNN)

The main function of convolutional layer is extracts features from image by using convolution operation. The dimensions of the feature maps are reduced by using pooling layer. The role of fully connected layer is to capturing global patterns and relationships in the input image by connecting every neuron from the previous layer to every neuron in this layer. Fully connected layer is trained by the extracted features by using backpropagation algorithm with help of training set and tested by using testing set.

5. Results and Discussion

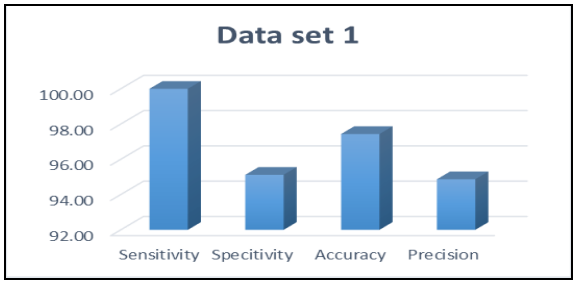

Figure. 4 Graph for performance comparison of the proposed system for data set 1.

The figure 5. Shows the performance comparison of the proposed system for data set 2, which is used to identify the Leaf Blasts (LB) decease. The proposed system has identified positives Leaf Blasts (LB) with 97.14 percent, negatives with 100 percent, total correct recognition with 98.68 percent, and positive classification with 100 percent.

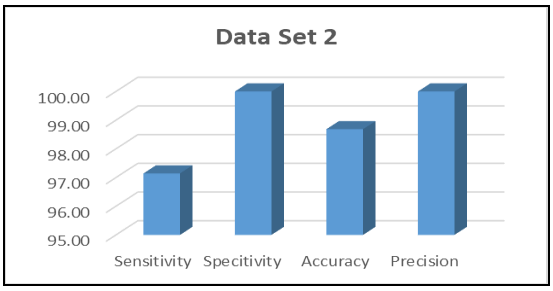

Figure. 5 Graph for performance comparison of the proposed system for data set 2.

The figure 6. Shows the performance comparison of the proposed system for data set 3, which is used to identify the Bacterial Blight (BLB) decease. The proposed system has identified positives Bacterial Blight (BLB) with 100 percent, negatives with 95.12 percent, total correct recognition with 97.3 percent, and positive classification with 94.29 percent.

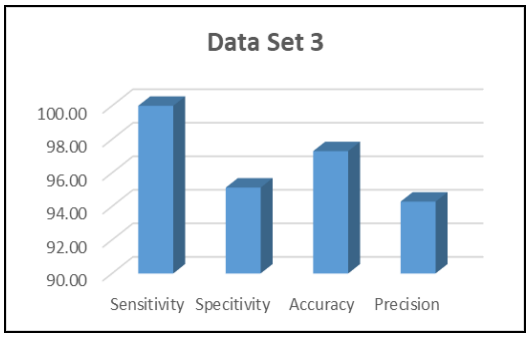

Figure. 6 Graph for performance comparison of the proposed system for data set 3.

The figure 7 shows the accuracy which is the total correct recognition of the classifier in the proposed system is better than the existing system.

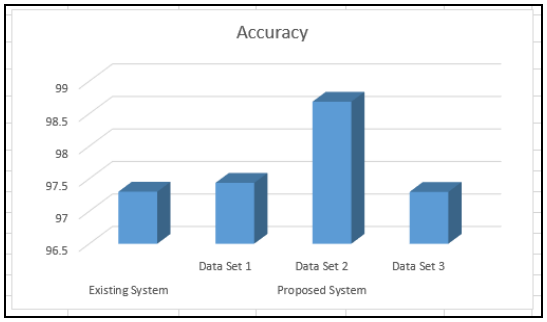

Figure. 7 The comparison between existing system and proposed system with respect to accuracy of the classifier

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6. Conclusion and Future Scope

In this work, we have proposed a system to classify the paddy deceases such as Brown Spots (BS), Leaf Blasts (LB) and Bacterial Blight (BLB). The proposed system contains median filter in the pre-processing stage, FCM for segmentation and CNN for classification. The CNN classifier is trained with the help of a training set and tested with the help of three testing data sets. The classifier results were compared with the existing system. The proposed system has shown better performance than the existing system. The maximum accuracy of the proposed system is 98.68 percent. The CNN classifier's performance can be enhanced even more by adding bigger and more varied datasets. Adding data from various demographic groups, communities, and imaging modalities can improve the generalizability of the model. Performance could be enhanced by carefully examining hyper parameters and optimizing the CNN architecture. It is possible to experiment with various network topologies, activation functions, and optimization strategies.

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