Rice Plant Disease Detection and Classification Techniques : A Survey

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***Abstract*—Rice/Paddy is the staple crop of India. India has the largest area under rice cultivation that includes the cultivation of brown and white rice. Rice cultivation brings employment and also helps to stabilize the Gross Domestic Product (GDP) by its vast contribution. In the field of agriculture and modern computer era, recognizing infection or diseases using plants' image is one of the keen research areas. This research paper provides a survey on various techniques and briefly discusses significant aspects of different classifiers and techniques used to detect rice diseases. Papers of the last decade are studied thoroughly, including the work carried on various rice plant diseases, and a survey is presented based on essential aspects. The survey focuses to distinguish different methods based on the classifier used. The survey gives insights of the different techniques used for the identification of rice plant disease. In addition, a hardware prototype and model using Convolutional Neural Network (CNN) is proposed that detects rice disease. It further identifies the type of rice disease into rice blast, rice blight, brown spots, leaf smut, tungro and sheath blight**.

Keywords—Rice leaf disease; feature extraction; SVM; KNN; CNN; multimedia sensors

I. INTRODUCTION

India is known for its agriculture as different types of crops are cultivated here. Rice is grown in nearly every state of India, with West Bengal having its highest production, followed by Uttar Pradesh and Tamil Nadu. India's more than three-fourth population depends on agriculture. Crop plant sickness or climatic changes can bring starvation [1]. This may have terrible effects on India's economy too. Hence identification of such diseases as early as possible becomes very important.

Earlier manual examination of the leaf was the only approach for disease identification. This was carried out by manual inspection of plant leaves or by referring a book to identify the disease [2]. Three major disadvantages of this method are, first, low accuracy, second, it is not possible to examine every leaf, and lastly, it is a time-consuming process. With advancement in science and technology, various ways are invented for identifying such diseases with high accuracy. Two approaches include image processing and deep learning. Image processing exercises different techniques like filtering, clustering, histogram study to detect the damaged region, and image processing algorithms to identify the diseases. On the other hand, in deep learning neural networks are used to detect the diseases.

Rice diseases are classified into four major types: bacterial diseases, fungal diseases, viral diseases, and disorders. bacterial infections include bacterial leaf streak, bacterial blight, grain rot, foot rot, and pecky rice. Some types of fungal diseases are brown spots, black horse riding, leaf blast, false smut, and any more. Rice tango, grassy rice stunt, rice yellow mottling are few types of viral diseases. Cold injury, white tip, alkalinity, and bronze are a few types of disorders in rice plants. Two major reasons for rice plant disease are first fungal/bacterial attack and second unexpected climatic change [3].

While dealing with rice diseases, there are few important things we need to consider, like, valid data collection, proper monitoring of rice plant and many more. Collecting samples of the infected rice plant is one of the important and essential steps. This can be done by installing multimedia sensors at different locations of the farm. This helps in monitoring the rice plant periodically. Also, climatic changes and their impact on the rice plant can be recorded and investigated. But this technique also has certain limitations like regular maintenance of the system, a shadow in the images captured which result in low accuracy.

This paper presents different rice diseases detection techniques and comparison is made amongst them on bases of classifiers used. Some common classifier used in recent past are: Support Vector Machine (SVM), K-Nearest Neighbour (KNN) and Artificial Neural Network (ANN). All these classifiers are explained in their respective section. Miscellaneous section includes survey whose classifiers are not known. In addition, a novel hardware prototype and Convolutional Neural Network (CNN) model is proposed that detects and identify type of rice disease.

The paper organized as follows: Section II summaries all the classifier's used for rice plant disease detection with their respective comparison tables. Section III contains the proposed work, and the proposed model is elaborated briefly. Section IV contains conclusion of the paper.

II. Literature Review

This section outlines some of the methods used to detect rice disease. Classifiers used in disease detection are considered as the subject of comparison.

A. SVM

SVM separates the data sets of the two classes and draws a line (decision boundary) also known as the Hyperplane. This hyperplane is drawn considering the extreme points plotted on the graph. Hence SVM is known as best divider of the two classes.

Three common diseases namely brown spots, rice blast and bacterial Blight were diagnosed using an automated system [4]. k-mean clustering was used to separate infected part of the image. Pesticides are also suggested for the identified diseases. Also a computer based automated structure was developed for disease diagnosing in article [5]. A 21-D feature vector is formed by selecting features from infected and non-infected leaf with the help of Gray Level Co-occurrence Matrix (GLCM) accompanied by colour moments of the leaf.

An extended version of the previous method where k-mean clustering method is used to extract details like color, SD, area, perimeter, etc. Components like shape, texture, and color are selected as features to classify these diseases [6]. Another method to detect the rice diseases includes image acquisition that consist of leaves of rice plant of both types; infected as well as non-infected. Images were taken from a village named Shertha in Gandhinagar, Gujarat-India [7]. Image pre-processing consist of obtained HSV model for the RGB colour model. As a part of Image segmentation, three clusters are formed from green cluster, background on the image and infected part of the image. Further diseases were classified using SVM.

Another research work used ostu's method to segment the rice plant leaves [8]. After segmentation various features were selected with the help of Local Binary Patterns (LBP) and a histogram was drawn. Further SVM was used as classifier and this research work successfully classified three major rice diseases, which are, bacterial leaf blight, leaf smut and brown spots.

An automated system was introduced which employed SVM classifier, which can identify leaf brown spot as per morphological changes of leaf [9]. Here image segmentation incorporated noise removal and computing radial hue of the infected region.

Another paper in which performance of CNN model with SVM was employed for rice plant diseases detection using 5932 on-field images [10]. Also, small CNN models like shuffle net and mobilenetv2 were tested on the basis of sensitivity, false positive rate, accuracy and specificity. It was found the ResNet50 plus SVM provides the best results.

Another research employed a method where the diagnosis of the rice diseases was divided into two stages in order to categories leaves into infected or non-infected [11]. In first stage, pre-processing is done wherein features were extracted from the colour moment and second stage focused on dividing the leaves into three major category, namely, leaf blight, brown spots, and leaf blast. This was done with the help of features extracted from gray level co-occurrence matrix. The proposed work also tested the accuracy for different classifiers like multi-layer perceptron, bayes' classifier, decision Tress, SVM and K-Nearest Neighbour (KNN). All SVM methods discussed in this subsection are compared and summarized in Table 1.

B. KNN

K-Nearest Neighbor (KNN) is the most straightforward machine learning algorithm. Based on similarities obtained between the new data and existing data, the algorithm classifies the new data into its suitable category.

Global threshold method was employed with KNN classifier for diseases identification [12]. Features extraction included calculating length of major and minor axis length, perimeter and area. Proposed system provided an accuracy of 76.59%.

Classification of diseases using minimum distance classifier and KNN was proposed in [13]. Information related to shape and colour of the infected images were extracted and were inserted into the system to classify four major diseases namely Rice brown spots, rice blast, sheath rot and bacterial blight. System provided an accuracy of 89.29%.

Another method wherein five attributes are selected using correlation-based feature selection technique of WEKA [14]. The process includes extraction of crucial features like color,

TABLE I. SVM BASED TECHNIQUES

Ref.	Dataset	Backgro-und of images	Edge detection	Colour space	Segmentation method	Feature Extraction	Classifier	Diseases identifiable	Accuracy	Are fertilizers provided?
[4]	30 samples	Not specified	No	Gray Scale from RGB	Green detection method and OSTU algorithm	4 features in terms of length is considered of eclipse and circle. 5th features is gray scale which is taken from RGB of rice blast	SVM	Rice blast of types 1. Chronic type 2. Acute type 3. White type	96.87% 85.71% 100%	No
[5]	20 samples	Not specified	No	RGB	K-mean clustering	Area, GLCM, Color, Fuzzy LBP	SVM ANN	1. Rice blast 2. Brown spots	SVM: 92.5% ANN: 87.5%	No
[6]	Not specified	Not specified	No	RGB	K-mean clustering algorithm	Colour: Mean, SD, RMS, Variance, Kurtosis. Texture: Contrast, Entropy, Correlation, Energy. Shape: Area	SVM	1. Brown spots 2. Bacterial blight 3. Leaf blast	90.9% 94.11% 85.71%	Yes
[7]	145 samples	Not specified	sobel	RGB	Edge detection	color, shape, and texture	SVM	1. brown spot 2. bacterial leaf blight 3. leaf smut	Not specified	No
[8]	120 sample	Background not included	Yes	RGB	OSTU algorithm	LBP: Texture HOG: Shape	SVM	1. Bacterial leaf blight 2. Leaf smut 3. Brown spot	LBP: 90% HOG: 94.6%	No
[9]	1000 samples	Not specified	No	RGB	OSTU algorithm	Radial distribution of Hue from the center to boundary	SVM	Brown spot	Not specified	No
[10]	800 samples	Not specified	Yes	Not specified	Fuzzy clustering	MobileNetV2 and shuffleNet were evaluated	SVM	1. Bacterial blight 2. Rice blast 3. Brown spots 4. Tungro	97%	No
[11]	600 samples	Not specified	Yes	Grey Scale	No	mean, skewness and kurtosis	SVM Bayes Decision Tree KNN MLP	1. Brown spots 2. Rice blast 3. Rice blight	SVM: 91.3%, 90.7%, 88.7% Bayes' : 93%, 92%, 92% Decision Tree: 88.3%, 87.3%, 87% k-NN 89.%, 88%, 86% MLP: 90%, 88.3%, 87.3%	No

the area from the leaf and feeding it to the KNN algorithm. KNN classifier along with decision Tree and naive bayes were used for generating more accurate results.

A system that uploads the acquired and segmented image to the cloud using compressed sensing was used in [15]. This system is useful to minimize the complexity of manual monitoring in the big farms and easily identify the diseases at a very early stage. K-Mean clustering segmentation methods is used to perform segmentation for infected area. The segmented image is reconstructed from the cloud using compressed sensing recovery algorithm. Feature extraction is carried out using GLCM method and is provided to KNN classifier which successfully detects bacterial blight, sheath rot, brown spots and rice blast respectively. All KNN methods discussed in this subsection are compared and summarized in Table 2.

C. ANN

The idea of ANN is created by visualizing the human brain. There are three layers in a neural network, namely, input layer, output layer and hidden layer. Neurons makes up the hidden layer. Layers are connected via channels. An activation function is generated which trigger's a particular neuron from

TABLE II. KNN BASED TECHNIQUES

Ref.	Dataset	Backgro-und of images	Edge detection	Colour space	Segmentation method	Feature Extraction	Classifier	Diseases identifiable	Accuracy	Are fertilizers provided?
[12]	330 samples	Black	No	RGB	OSTU algorithm	Geometrical feature like Area, Major Axis, Minor Axis and Perimeter	kNN	1. Rice blast. 2. Brown spots	76.59%	No
[13]	115 samples	Not specified	No	RGB	No	Shape and color	kNN MDC	1. Bacterial blight 2. Rice blast 3. Rice brown spot 4. Rice sheath rot	kNN: 87.02% MDC: 89.23%	No
[14]	480 samples	White	No	Not specified	No	Top 5 attribute are selected using correlation based features selection technique of WEKA	kNN J48(Decision Tree) Navie Bayes Logistic regression	1. Leaf smut, 2. Bacterial leaf blight 3. Brown spot diseases	Logistic Regression: 75.46% 70.83% kNN(K=1): 98.84%, 91.66% kNN(K=3): 85.64%, 72.9% Decision Tree: 94.9%, 97.9% Naive Bayes: 58.7%, 50%	No
[15]	115 samples	Not Specified	No	YCbCr	No	Color and shape	MDC and k-NN	1.bacterial blight 2.rice blast 3.brown spot 4. sheath rot	k-NN => 87.02 % MDC => 89.23 %	No

the hidden layer. Number of hidden layers vary with the complexity of the pattern.

An automated system that uses machine learning algorithm for classifying leaf to be healthy or infected and further classifying the diseases was proposed in another work [16]. Leaves were captured from a distance of 25cm and features like standard deviation, energy, correlation and many more were used to train the system. 90% accuracy was achieved in identifying the infected leaf.

Another research work implemented a light-controlled module to capture images [17]. Height and width of the box were calculated by keeping in mind the distance of the object from the camera and the amount of light entering the box. Thresholding and masking were the main procedure carried out on the converted the leaf into binary-level image. Diseases like rice blast, leaf blast and brown spots were identified.

Deep CNN is used in identifying diseases in [18]. First pre-processing is carried out on the data set of 500 images. With the help of this pre-processed image the CNN model is trained. Experiments results show's that CNN is best classifier in terms of speed and accuracy. Another research work used fractal descriptor for identifying four major rice plant diseases, namely, brown spots, leaf blight, leaf blast and tungro [19]. Manually extracted images were used for the study. Saturation component was used in classification processes with PNN classifier. Accuracy of 83% was achieved.

A mobile application which used fuzzy entropy and probabilistic neural network was developed by researchers in article [20]. Feature extraction is done using fuzzy entropy and are given to PNN classifier which helps to detect Tungro, brown spots, leaf blight and leaf blast rice diseases. All ANN methods discussed in this subsection are compared and summarized in Table 3.

D. Miscellaneous

An expert team was appointed having 15 normal people and 20 agricultural expert in order to identify the type of diseases [21]. This expert system was able to identify few diseases, namely, False Smut, Rice bug and sheath rot. Identification process was carried out via features obtained from the leaves like colour of spot, shape, size, infected part etc.

Another method where various segmentation methods were carried out with normal and abnormal leaves. Implementation work was carried out using Matlab 7.5 tool [22]. It was found that region growing algorithm works best as a segmentation technique.

An experiment on artificial inoculation rice blast was conducted in article. This was carried out on three locally grown varieties of Japonica rice [23]. A push-broom system was designed in order to capture the leaf images. Conversion of reflective values to DN values was done and the result was given to PROCWT system for classification of the diseases.

TABLE III. ANN BASED TECHNIQUES

Ref.	Data set	Backgro-und of images	Edge detec-tion	Colour space	Segmentation method	Feature Extraction	Classifier	Diseases identifiable	Accuracy	Are fertilizers provided?
[16]	300 samples	Not specified	No	HSV	K-mean algorithm	Mean, SD, GLCM (Energy, Contrast, Correlation, Homogeneity)	ANN	Checks for Rice blast or normal leaf	For training : 99% & 100% For testing: 90% & 86%	No
[17]	134 samples	Black	No	HSV	OSTU algorithm	1. fraction covered by the disease 3. arithmetic mean values for R,G,B 4. Standard deviation for R, G, and B 5. Mean value of H, S, and, V	ANN	1. Bacterial leaf blight 2. Brown spot 3. Rice blast.	1. 100% 2. 98% 3. 100%	No
[18]	500 samples	Not Specified	No	RGB	No	No	CNN	1. Rice blast 2. Brown spots	95.48	No
[19]	40 samples	Not specified	No	Not specified	No	No	PNN	1. Leaf blast 2. Brown spots 3. Leaf Blight 4. Tungro	83.00%	Yes
[20]	67 samples	Not specified	No	RGB	Fuzzy entropy	No	PNN	1. Brown spot 2. Leaf blast 3. Rice Tungro 4. Bacterial leaf blight.	1. 100% 2. 100% 3. 76% 4. 96%	No

Another author used Euclidean distance as his classifier to identify the rice diseases [24]. First, segmentation of images was done using K-mean clustering algorithm. Then GLCM algorithm was used to extract texture features and metric & Eccentricity algorithm was to trace the shape pattern. Obtained information was given to Euclidean classifier for further analysis.

With the help of PHP and MySQL, an expert system was designed to identify the rice disease [25]. This study was carried out in Meghalaya-India and had three major sections, First, to identification of common rice diseases in the state. Second, to represent it via computer program and lastly demonstrating the expert system to the common people.

Another study was carried out wherein the images of the rice plant were captures via smartphone, further transferring it to computer for RLB detection [26]. The RLB disease severity stage was displayed as output and this information was used by farmer's and agricultural expert for detail study.

Another disease detection techniques include the classification of diseases based on the RGB % using Image processing [27]. This technique takes the RGB percentage of the infected leaf into consideration for disease detection; based on the RGB % value, leaves are grouped into different classes. Further, this information is fed into gaussian naive bayes, that categories disease into different categories. Advantage of this method's is that it requires less time to identify the disease, but identifying diseases based on RGB % may produce a less accurate result.

An optimistic fuzzy interface system was designed for automatically identifying the rice disease [28]. Pre-prossessing includes removal of converting the image into RGB band and using median filtering to remove noise from the green band. Then the colour features and textural features are extracted from the green band which are given to the OFIS system which classifies the leave image as infected or not-infected. All other methods discussed in this subsection are compared and summarized in Table 4.

TABLE IV. MISCELANEOUS TECHNIQUES

Ref.	Data set	Backgrou-nd of images	Edge detecti-on	Colour space	Segmenta-tion method	Feature Extraction	Classifier	Diseases identifiable	Accuracy	Are fertilizers provided?
[21]	12 samples	Not specified	No	Not specified	No	No	Expert system	Tungro diseases	73.81%	No
[22]	Not specified	Gray scale	No	Not specified	RG, MS	No	No	General rice disease	Not specified	No
[23]	137 samples	Not specified	Yes	Not specified	No	Chlorophyll	PROCWT	Rice blast	Not specified	No
[24]	40 samples	Background not included	No	RGB	K mean clustering	Energy, contrast, correlation, homogeneity and shape pattern	Euclidean distance algorithm	1. Bacterial leaf blight 2. Brown spots	100%	No
[25]	Not specified	Not specified	No	RGB	No	No	No	1. Brown Spot 2. Sheath Rot 3. Sheath Blight 4. False Smut	Not specified	No
[26]	Not specified	Background was removed	Yes	HSV	Color image segmentation	Yes	Not specified	1. Rice blast	Not specified	No
[27]	67 samples	Blue	No	RGB	No	Only % of RGB required	Bayes	1. Rice blast 2. Rice brown spots 3. Rice Bacterial blight	5. 89% 6. 90% 7. 90%	Yes
[28]	85 samples	Not specified	No	RGB	No	Features like Mean, SD, Area, Perimeter &Eccentricity	OFIS	Identifies whether the leaf is normal or abnormal	96% with OFIS	No

III. PROPOSED METHOD

As shown in Fig 1, the proposed method for the identification of rice disease has the following steps:

Data acquisition: The collection of the rice plant images with other soil and environmental parameters is the first step. In proposed work, hardware module comprises of raspberry pi board with scalar and multimedia sensors. Solar panel is used for energy harvesting. Multimedia sensor (camera) is mounted on metallic pole and the vertical movement is controlled with the help of motor. Scalar sensors like temperature, soil, humidity, moisture are used to collect scalar data which can be used along with image data for further processing and analyzing. Scalar and image data is collected periodically and uploaded on the cloud to monitor life cycle of rice plant.

Pre-processing: Collected images may be irregular in nature, so pre-processing is carried. Here RGB coloured images are preferred over HSV because of their clarity and also conversion of RGB to HSV may be time consuming. Further, feature extraction process is carried out, which are then given to the classifier.

Classification: The CNN classifier is used to classify whether the leaf is infected or not and then identify the diseases accordingly.

In proposed work, python-based computer vision and machine learning libraries such as pandas, numpy, TensorFlow are used for processing the received data and identification of the diseases. With the help of CNN model, an outstanding accuracy of 96% was achieved for classification of major diseases namely Rice blast, Rice blight, Brown spots, leaf smut, tungro and sheath blight as shown in Fig 2.

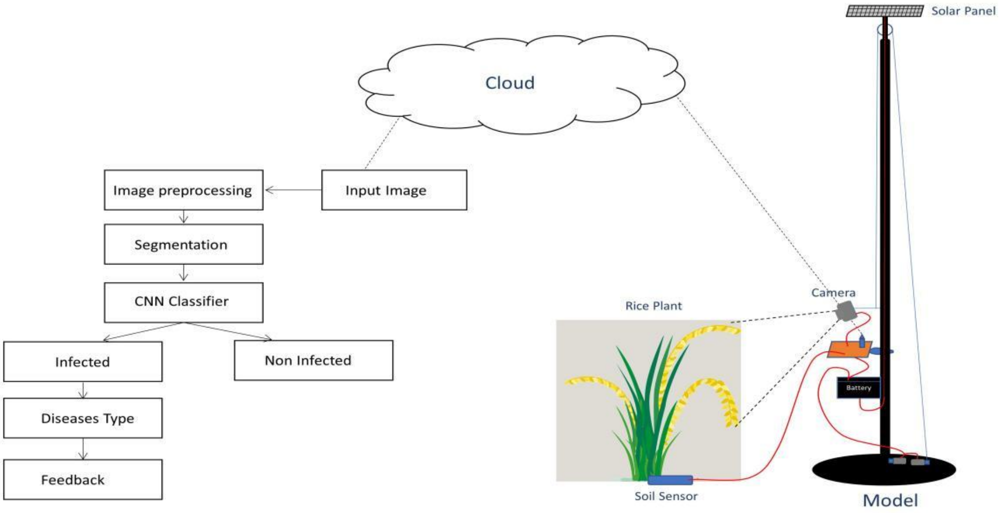

Fig. 1. Proposed Architecture

	precision	recall	f1-score	support
blast (class 0)	0.93	0.86	0.90	50
blight (class 1)	0.96	0.98	0.97	50
Brownspot (class 2)	0.98	0.96	0.97	50
leaf_smut (class 3)	0.96	0.98	0.97	50
sheath_blight (class 4)	0.94	1.00	0.97	50
tungro (class 5)	1.00	1.00	1.00	50
accuracy			0.96	300
macro avg	0.96	0.96	0.96	300
weighted avg	0.96	0.96	0.96	300

Fig. 2. Proposed Architecture

IV. CONCLUSION

Rice disease is the major issue encountered by most farmers; hence its early detection is very essential. With advancement in science, identification of rice disease is much easier than manual inspection which was carried out in earlier days.

This research paper summarized various methods used for identification of rice diseases based on the classifier used. Also, it was found that CNN classifier holds outstanding record in pattern recognizing problem which is core concept of image processing. Our proposed model that works on CNN shows promising results in achieving good accuracy.

In future work, we want to compare our CNN model with existing state-of-art techniques. In addition, we want to customize our hardware prototype and CNN model for other types of crop plants.

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