Rice Plant Disease Detection using Image Processing: A Review

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Abstract

Rice plant diseases identification is significant in the forthcoming progress of the agricultural field. Since last decade identification of plant disease using image processing techniques have played vital role in agriculture research. Various methods of disease detection, classification and quantification developed and applied to crops. This paper reviews related research on different diseases classification techniques that can be used for plant leaf disease detection. Also based on image segmentation, feature extraction, feature selection and classification methods comparative study is prepared. Also this paper presents an algorithm for image segmentation technique which is used for automatic detection and classification of plant leaf diseases.

Keywords: Rice plant diseases; image segmentation; feature extraction; feature selection; classification

1. Introduction

The agricultural soil group is more than just being a feeding sourcing in today’s world. Indian market is highly reliant of agricultural productivity. Rice is deliberate as a major source of food among the rural population and also it is considered and the second most cereal crop cultivated over the world.

Rice demand expected to grow faster than the production in most countries. In this situation, damage of rice crop by any cause is unacceptable \cite{1}. Detection of rice plant disease and its strictness has always been demanding. Earlier naked eye observation (visual analysis) was the only available technique to diagnosis the rice disease. This technique requires continuous monitoring of the crop field for the correct estimation of disease by expert of this field. As the visual analysis requires constant human interpretation, the process (visual analysis) tends to be very expensive, cumbersome and time-consuming for large areas of plants. The exponential growing population changes the demand of supply of food produce scenario rapidly. Such situation forces the society, as a whole, to think for, use of advanced technology so that early and accurate estimation of disease for the implementation of remedial measure can applied at the right time. Image processing techniques are proving one of the accurate and economic practices for measuring the parameters related to various plant diseases.

Section 2 presents related work. Section 3 presents types of rice crop diseases. Section 4 presents Growth Phases of Paddy Crop and its Diseases. Section 5 describes Basic Methodology of Image Processing for Plant disease detection. Section 6 presents
research gaps. Section 7 describes challenges. Finally, Section 8 summarizes work in the form of conclusion.

2. Related Work

Image processing techniques are prove one of the accurate and cost-effective practices for measuring the parameters related to various plant diseases. In this paper a precise survey and relative analysis of different image processing techniques is included which is applicable for analysis of plant diseases. The Growing period of rice crop comprises: (1) Germination, (2) Vegetative Phase, (3) Reproductive phase, (4) Ripening phase [2]. In germination, at first root and shoot crop up from the seed [4]. The vegetative phase is from uprooting of plant to initiation of panicle. The reproductive phase includes the emergence of panicle from tiller to complete growth of panicle. Then in ripening phase, the panicle is mature enough so that the kernel inside the grain is completely grown. The disease can affect any part or any growing stage of rice crop.

[19] Fuzzy C means average segmentation used for leaf spot disease detection on cucumber plant. [21] Applied Color image thresholding for rice leaf blast detection When trained pixels are not available, the unsupervised classification is used. Support Vector Machine: SVM is a powerful discriminative parallel classifier that models the choice limit between two classes as an isolating hyper-plane. This hyper-plane endeavors to part, one class comprises of the objective-preparing vector, and alternate class comprises of the preparation vectors from an impostor (foundation) population [33,34]. Utilizing the named preparing vectors, SVM analyzer finds an isolating hyper-plane that reduce the edge of segmentation between these two classes. Probabilistic Neural Network: PNN dependent on the statistical methodology called Bayesian classifiers. PNN is a feed-forward system involving input, covered up and yield layers. The hidden layer otherwise called example layer. Specifically, design layer comprises of Bayesian classifier. PNN worked after using a non-parametric estimator to acquire multivariate probability and density function. At present, PNN remains the most fitting neural design for discovery of rice leaves contaminated eventually rice leaf roller. PNN design over noticeable and Shortwave Infrared (SWIR) ghostly groups. PCA utilized to change unmistakable and SWIR groups into primary component range. PNN anticipated both ailment and irritation disease. The combinational PCA and PNN results as best indicator of disease infected in rice plant [26-28]. Convolution Neural Network: CNN is deliberated as an important unsupervised profound learning design that learns ‘filters performing convolution’ in the image domain. A measure distinction among CNN and ordinary NNs is that CNN roused from retinal fields in the vision framework. Sequentially, CNN is a coordination of natural vision and neural framework. CNN is an intricate design which sets aside impressively greater opportunity to prepare the neurons. Regardless, it has astounding order accuracy is very high. [29].

3. Rice Crop Diseases

This section describes information about the paddy diseases with their appearance. The paddy diseases are due to many constraints such as pathogens, insect pest, deficiency of nutrients and unusual environmental condition [3-5]. Plant pathogens can be parasitic, bacterial, viral or nematodes and can harm plant parts above or underneath the ground.
Figure 1: Types of Paddy leaf Diseases

a. *False Smut*
False Smut appears as silvery-white structures and later as orange smoke/dust, when infected later develops panicles. The disease cycle continue late into the growing season and has caused the loss of direct yield so far. Disease favors during the rainfall and high humidity; Land with extreme nitrogen content [6].

b. *Sheath Blight*
Sheath blight in rice plant caused by fungi *Rhizoctonia solani* Kuhn that infected the straw of rice. It occurs when sclerotic fall off the straw before or during the time of rice harvesting. Initial lesions on leaf sheaths, proves the presence of sclerotia. It filled or empty grains, such that with the underneath panicles [7].

c. *Rice Blast*
Blast of rice is major disease since many decades in Middle Gujarat and since last two decade in South Gujarat. Pathogen attacks all the aerial parts of plants at any stage of crop growth right from germination to harvest [8-10]. The disease occurs as seedling blight, leaf blast, node blast, and neck or panicle blast and grain spot. Seed and soil borne infections, during germination become reason for death of seedling. Leaf blast is characterized by production of large spindle shaped lesions with ashy grey centers with brown margins drastically reduce crop growth. The infected node or neck tissues became soft and rotted. The node or neck blast treated as an effective stage of the disease attacking prior or after flowering and grain formation, causing drastic reduction in grain quality and quantity of produce. The infection on grain produced dark brownish black spot [11-14].

d. *Leaf Scald*
The symptoms are narrow reddish-brown wide bands. Sometimes lesions are at leaf edges with yellow or golden borders [11-13].

e. *Brown spot*
This disease occurs on leaves of the rice plant. The symptoms of the disease are round to oval shape with dark brown lesions [11-13].

f. *Bacterial leaf blight*
Symptoms contain elongated lesions on leaf tip, lesions are several inches long and it turn into yellow from white due to effect of bacteria [11-13].

g. *Bakane*
The affected Rice plant may be of abnormal elongation in the seedbed and loss the actual development phase. Thus, the seed exist in the growing stage; they exhibit empty panicles field –with yellow shades leaves. Reduced tillering and drying of leaves at late disease terminates the bucket seedlings at early phase. Infected seedlings are taller than ordinary plants and are thin and yellowish-green at the seedling stage, bakanae can be found in the vegetative stage, infected plants are taller than the typical plants and have a couple of tillers and yellow-green leaves [12,13].
Rice Hispa is a very serious insect pest of rice. Translucent white patches that are parallel to the leaf veins. White, grub like larvae are seen mining through leaf tissues. Spiny black metallic beetles feeds on the upper surface of leaves producing bold white streaks.

![Images of rice leaves showing symptoms of diseases](a) (b) (c) (d)

Figure 2. (a) Brownspot (b) Healthy (c) Hispa (d) LeafBlast

4. Growth Phases of Paddy Crop and its Diseases

Rice crop cultivation undergoes three general growth phases: vegetative, reproductive, and ripening. Besides these three phases, there is another phase prior to development of radicle and plumule from the seed known as Germination. After the embryo germinates, it grows out of the seed and known as a plantlet or seedling. Diseases in different stages are
A] Germination phase – Seed Rot
Seed rot ia caused by fungal pathogen. The spore of fungi i.e. conidia carried by rice seed at the time of germination, the fungus grows which lead dead or weakening of seedling. Besides these factors, germination of seed is more confide in quality of seed use for seedling purpose. For satisfactory farming, germination test is needful in a certain degree [6, 7]. The measurement of seed quality or selection of good seeds is an important factor for successful farming.

B] Vegetative Phase-
Crown rotor foot rot (also known as Bakane), Leaf blast, Brown spot, Sheath, blight, Leaf scald, Leaf smut, Stack burner, Alteraria leafspot, hiteleafstreak, Whitetip, Bacterial earblight, Crownsheathrot, Collar blast, Node blast . Vegetative phase the rice crop is affected by various diseases caused by bacteria, fungi & virus i.e. Crown rot or foot rot (also known as Bakane), Leaf smut. Stack burn or Alternaria leaf spot, White leaf streak. White tip, Bacterial leaf blight, Crown sheath rot, Collar blast, Node blast. The sample image of different rice diseases appear in vegetative phase illustrated in Figure 3.
Besides different diseases, mineral deficiency is a major constraint factor that affects the growth of rice crop. Rice crop required favorable nutritional balance of mineral or macronutrient like potassium, magnesium, nitrogen, phosphorous and zinc for its proper growth. The deficiency of minerals observed in its leaves because of deformity in shape and Color appeared in leaves.

C] Reproductive and Ripening Phase - Rotten neck blast, Downy mildew, White ear head, Panicle blast, Bacterial panicle blight.

Reproductive phase starts with appearance of panicl from stem (known as Booting) and ends with full visible of panicle (known as heading). The ripening phase is time of transformation of flower to complete mature grain, suitable enough for harvesting and approximately take 15-40days [15]. In this two phase the diseases as rotten neck blast, White ear head, Panicle blast and Bacterial panicle blight are appear.

5. Basic Methodology of Image Processing for Plant disease detection
Advance automated technique like image processing and machine learning is needful to implement for identification of paddy diseases. The systematic steps of image processing are briefing in following section. The content of sub-section includes comparative study on image segmentation, feature extraction, feature selection and classification applicable for plant disease diagnosis. It also outlines the current achievements and limitations.

(a) Image acquisition
It is the very first step that requires capturing an image with the help of a digital camera. Preprocessing of input image to improve the quality of image and to remove the undesired distortion from the image. Clipping of the leaf image is performed to get the interested image region and then image smoothing is done using the smoothing filter. To increase the contrast Image enhancement is also done. Mostly green colored pixels, in this step, are masked. In this, we computed a threshold value that is used for these pixels. Then in the following way mostly green pixels are masked: if pixel intensity of the green component is less than the pre-computed threshold
value, then zero value is assigned to the red, green and blue components of the this pixel. In the infected clusters, inside the boundaries, remove the masked cells. Obtain the useful segments to classify the leaf diseases.

Table 1, describes types of rice plant diseases, the place of image acquisition and different methods of assessment that the researchers adopted.
Table 1 A Table presenting place of image acquisition and respective evaluation patterns

<table>
<thead>
<tr>
<th>Reference article &amp; patterns</th>
<th>Diseases</th>
<th>Image acquisition</th>
<th>Image evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phadikar and Sil (2008)</td>
<td>Rice Blast and Brown spot</td>
<td>East Midnapur and South Bengal, India</td>
<td>Contrast&lt;br&gt;Color space to HSI color space</td>
</tr>
<tr>
<td></td>
<td>and Brightness enhanced, RGB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanyal and Patel (2008)</td>
<td>Rice leaf blast and Brown spot</td>
<td>Not mentioned</td>
<td>RGB</td>
</tr>
<tr>
<td>Libo and Guomin (2009)</td>
<td>Rice Brown spot</td>
<td>Northern part of Ningxia Hui, China</td>
<td>RGB Color</td>
</tr>
<tr>
<td></td>
<td>space to Lab color space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rice blast, and Bacterial leaf blight

Lu et al. (2017) Brown Spot, Rice blast, false smut, baka-nae, sheath blight, sheath rot, bacterial sheath, Seedling Blight, Bacterial wilt and Bacterial leaf blight

Median filter

China National Rice Research Institute- Fuyang, China

RGB Color space to HSV color space, Histogram equalization

International Rice research institute, Los banos, Laguna, Philippines

ZCA whitening method

Heilongjiang Academy of land reclamation sciences, China

Prajapati et al. (2017) Leaf smut, Brown Spot and Bacterial Leaf Blight

Shertha, Gandhi nagar, Gujarat, India RGB color space to HSV color space, Background removal
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Disease(s)</th>
<th>RGB Color space to</th>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhagyashri and Gajanan (2017)</td>
<td>Brown Spot and Leaf Blast</td>
<td>Lab color space</td>
<td>Rice Research center Karjat, Maharastra, India</td>
<td></td>
</tr>
<tr>
<td>Narmadha and Arulvadivu (2017)</td>
<td>Narrow brown spot, Brown Spot, and Blast</td>
<td>Gray scale color space</td>
<td>Internet</td>
<td></td>
</tr>
<tr>
<td>Archana and Arun (2018)</td>
<td>Brown Spot and Bacterial Leaf Blight</td>
<td>HSV color space</td>
<td>Not mentioned</td>
<td></td>
</tr>
<tr>
<td>Gayathridevi and Neelamegam (2018)</td>
<td>Leaf streak, Leaf blast, False smut, Brown spot and Bacterial Leaf Blight</td>
<td>Median Filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maohua et al. (2018)</td>
<td>Rice blast lesions</td>
<td>Nanjing Agricultural University RGB Color space to YCbCr space</td>
<td>Nanjing Agricultural University</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Authors</th>
<th>Disease(s)</th>
<th>Location</th>
<th>Color Space Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takuya and Yutaka (2018)</td>
<td>Rice blast</td>
<td>Not mentioned</td>
<td>RGB</td>
</tr>
<tr>
<td>Ramesh and Vydeki (2018)</td>
<td>Rice blast</td>
<td>Panpoli, Tirunelveli, India</td>
<td>RGB Color space to HSV color space</td>
</tr>
<tr>
<td>Taohodul et al. (2018)</td>
<td>Rice blast, Rice bacterial blight, and Rice brown spot</td>
<td>International Rice Research Institute</td>
<td>RGB</td>
</tr>
<tr>
<td>bu Bakar et al. (2018)</td>
<td>Rice leaf blast</td>
<td>Malaysian Agricultural Research and Development Institute, Malaysia</td>
<td>RGB Color space to gray scale color space Brown spot</td>
</tr>
<tr>
<td>Komal et al. (2019)</td>
<td>Bacterial Leaf Blight, False Smut, and Rice Research Institute, Lahore, &amp; Punjab, India</td>
<td>Pakistan</td>
<td>RGB Color space to gray scale color space Brown spot</td>
</tr>
<tr>
<td>Wan-Jie et al. (2019)</td>
<td>Rice Blast</td>
<td>Institute of Plant protection, Jiangsu, China</td>
<td>RGB</td>
</tr>
<tr>
<td>Chowdhury et al. (2019)</td>
<td>Brown spot, Neck blast, Bacterial leaf</td>
<td>Bangladesh Rice Research Institute,</td>
<td>RGB</td>
</tr>
</tbody>
</table>
Table 2. Review of Different Techniques applied in various image processing phases for plant disease detection

<table>
<thead>
<tr>
<th>Image Processing Phases</th>
<th>Reference and Year</th>
<th>Objective</th>
<th>Methodology</th>
<th>Performance Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[17] 2017</td>
<td>Diagnosing plant Disease</td>
<td>Gaussian smooth approach</td>
<td>Accuracy 90.96</td>
</tr>
<tr>
<td>Image Segmentation</td>
<td>[18] 2017</td>
<td>Identification of mineral deficiency</td>
<td>Fuzzy C mean and K-Mean Clustering</td>
<td>Accuracy (FCM)= 92%, Accuracy(K-Mean)=85%</td>
</tr>
<tr>
<td></td>
<td>[19] 2017</td>
<td>Cucumber leaf spot disease detection</td>
<td>Fuzzy C mean Average segmentation</td>
<td>Error=0.12% and exhibited an efficiency accuracy in the detection of the disease</td>
</tr>
<tr>
<td></td>
<td>[21] 2018</td>
<td>Rice leaf blast Detection</td>
<td>Color image thresholding</td>
<td>The severity of the disease is adequately classified</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>[22] 2007</td>
<td>Texture Extraction</td>
<td>Image Processing</td>
<td>Accuracy= 88.56%</td>
</tr>
<tr>
<td></td>
<td>[23] 2018</td>
<td>Evaluation of soybean leaf defoliation Color Extraction</td>
<td>Accuracy= 96%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[24] 2018</td>
<td>Detection of Leaf Disease Feature extraction</td>
<td>Edge detection</td>
<td>Accuracy= 82%</td>
</tr>
<tr>
<td>Classification</td>
<td>[26] 2018</td>
<td>Rice disease determination</td>
<td>Principal Component Analysis and Neural Network</td>
<td>Accuracy of BP neural network 95.83%</td>
</tr>
<tr>
<td></td>
<td>[32] 2017</td>
<td>Detect the classification of leaf disease</td>
<td>K-Mean Clustering</td>
<td>Accuracy FCM=95% K-Mean=85.05%</td>
</tr>
</tbody>
</table>
(b) Image Segmentation

Image segmentation meant way toward sectioning default image into its tremendous sections or objects. It is a standout amongst the most troublesome errands in computerized image processing. It is used to find desired objects. Segmentation implies segment of picture into assorted piece of same skin tone or having some resemblance analysis implies distributing image into various piece of same components or having some similarity. The segmentation ought to be conceivable using distinctive Algorithms like Otsu’s methodology, k-means clustering, conversion of RGB image into HIS model [18, 19].

Rishi et al. 2015 [20] discussed a technique based on heterogeneous plant disease with feasible and apprehension respectively. Otsu method, image compression, image cropping and image de-noising including K-means clustering are the techniques involved in the articulation of the disease images. Bakar et al. 2018 [21] proposed a methodology to detect RLB and classify into three category according to its severity. It includes the image pre-processing, image segmentation and image analysis where Hue Saturation Value (HSV) colour space is used. To extract the region of interest, image segmentation is applied, and pattern recognition based on Multi-Level thresholding approach is used.

(c) Feature Extraction

The feature extraction technique plays an important role in image classification. The features are the main parameters that are involved for classification of image.

(d) Texture Extraction: Texture extraction is determined as the example of information or course of action of the structure with random interval. Texture attributes such as appearance of object size, shape, thickness, characterization, extent of its basic properties are considered during texture extraction. A fundamental stage to accumulate such features through texture extraction called as texture component extraction. Sequentially, the importance of texture data, texture component extraction is a core limit in various image-processing applications like remote detecting, biomedical imaging and object based image [22].

(e) Color Extraction: Color extraction is an important factor of distinctive classes. Digital image processing produces color estimations which are extremely useful [25]. An image pixel typically addressed in the RGB space, in which the color space at each pixel addressed as a combination of RGB. Other color spaces like the HIS and CIE color space model mostly used in various other segmentation procedures where their benefits and constraints analyzed announced and examined. It is understood that Euclidean separation of the distinct color is proportional to the variation that human visual impact over CIE Lab color space [23].
(f) **Edge Detection:** Edges in image are the portions with solid boundaries and object with one pixel then onto the following can make genuine assortment in the picture quality. Edge detection is an image processing strategy for finding the limits inside the corresponding image. It works by distinguishing discontinuities in brightness. Edge recognition utilized for image segmentation and information extraction in regions, for example, picture processing, computer vision, and machine vision [24]. Accordingly, the specific edges used for limit estimation and extraction in the scene. The Table 4 illustrates the existing feature extraction techniques that conducted by many researchers for diagnosis of plant diseases.

(g)**Classification:** In a typical classification system image captured by a camera and then processed. In Supervised classification, most importantly preparing occurred through known gathering of pixels. The trained classifier used to group different pictures. The Unsupervised order utilizes the properties of the pixels to bunch them, these gatherings known as group, and process called clustering [35, 32]. The numbers of clusters are decided by users.

6. **Research Gaps**

This existing literature presents various image acquisition techniques and approaches used in various image processing phases for plant disease detection. After study some research gaps are identified which are described below:

(i) In the majority of the research, the crop disease dataset was used for evaluation of performance of classification. Even though this dataset has a several kinds of plant and their diseases, it has a simple background. However, for a practical situation, the real background should be considered.

(ii) Hyperspectral/multispectral imaging is a rising technology used in many areas of research. Efficient classification such as cascaded approach is required to detect the plants’ diseases even before their symptoms are clearly apparent.

(iii) An additional and more efficient way of visualizing the spot of disease in plants should be introduced as it will save costs by avoiding the redundant use of fungicide/pesticide/herbicide.

(iv) The sternness of plant diseases varies with the time, therefore, classification models should be enhanced to facilitate them to identify and classify disease during their entire cycle of occurrence.

(v) A broad study is essential to identify factors affecting the discovery of plant diseases, like the classes and size of datasets, learning rate, illumination, and the like.

7. **Challenges**

Detection of rice plant disease is a difficult field for the researcher working on the domain of image processing and artificial intelligence because there are many challenges. In this
section, key challenges that researcher faces are mentioned.

The major challenge in this area is image acquisition phase, as further phases depend on this phase. The challenges are
(i) While acquiring images, the noisy background is added due to varying climatic conditions.
(ii) There are differences in contrast between the leaves and panicles of rice.
(iii) The variations in climate conditions cause’s variations in lighting. This might reflect in low intensity values of an input image. Also it directly affects the results of segmentation phase, so do the feature extraction phase.

In the segmentation phase of rice plant disease identification, the major task would be separating the disease area and the background. The challenges that exist during the segmentation process are
(i) Sizes of the disease on the leaf are variable
(ii) Huge processing time is needed during region growing segmentation method; (iii) Changes in disease color create large variability in colors and make the color based segmentation process difficult;
(iv) There are varying changes in the scale and origin of the diseased part and the background.

These above challenges directly have impact on the accuracy and also degrade the overall performance.

7. Conclusion

In this study, many forms of image processing methodologies and artificial intelligence involved in identifying and classifying the rice plant diseases were discussed. The survey covers six key steps such as Image acquisition, Image Preprocessing, Image Enhancement, Image Segmentation, Feature Extraction, and Image Classification. From the literature review, it was understood that all the research addressed was mostly confined to Rice blast or Brown spot, and precision was achieved only by using the auto weight allocation within the context of deep learning architecture. We conclude that the collection of images and preprocessing of images play an important role in the overall process, as they impact on the accuracy of segmentation. We also conclude that K-means clustering was the most used technique of segmentation to segment the infected area from the background. Color features are also the most prominent features which can be feed forwarded to different classifiers to identify and classify Rice plant diseases. In this manner, their endeavors are expected to execute a powerful, quick, precise and automatic framework that is used for disease identification on the Rice plant unaffected leaves.

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