International Journal of Future Generation Communication and Networking
Vol. 13, No. 4, (2020), pp. 4899–4918

Rice Plant Disease Detection using Image Processing: A Review

Mrs Nilam Sachin Patil[1], Dr. E Kannan[2]
[1]Research Scholar, [2]Professor

[1,2] VelTech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Chennai

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 [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

ISSN: 2233-7857 IJFGCN

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 threasholding 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.

ISSN: 2233-7857 IJFGCN

Figure1: 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 leafs. 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].

h. *Hispa*

ISSN: 2233-7857 IJFGCN

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.

(a)

(b)

(c)

(d)

Figure2.(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

ISSN: 2233-7857 IJFGCN

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 eafblight, 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 panicle 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

ISSN: 2233-7857 IJFGCN

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 .

ISSN: 2233-7857 IJFGCN

Table 1 A Table presenting place of image acquisition and respective evaluation patterns

Reference article	Diseases	Image acquisition	Image evaluation patterns
Phadikar and Sil (2008)	Rice Blast and Brown spot	East Midnapur and South Bengal, India	Contrast and Brightness enhanced, RGB Color space to HSI color space
Sanyal and Patel (2008)	Rice leaf blast and Brown spot	Not mentioned	RGB
Libo and Guomin (2009)	Rice Brown spot	Northern part of Ningxia Hui, China	RGB Color space to Lab color space
>Yao et al. (2009)	Rice leaf blast, Rice sheath Blight, and Rice Bacterial Leaf Blight	Orillo et al. (2014)	Brown Spot,

ISSN: 2233-7857 IJFGCN

	Rice blast, and Bacterial leaf blight		
		China National Rice Research Institute- Fuyang, China	Median filter
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	International Rice research institute, Los banos, Laguna, Philippines	RGB Color space to HSV color space, Histogram equalization
		Heilongjiang Academy of land reclama- tion sciences, China	ZCA whitening method
Prajapati et al. (2017)	Leaf smut, Brown Spot and Bacterial Leaf Blight	Shertha, Gandhi nagar, Gujarat, India	RGB color space to HSV color space, Back- ground removal

ISSN: 2233-7857 IJFGCN

Bhagyashri and Gajanan (2017)	Brown Spot, and Leaf Blast	Rice Research center Karjat, Maharastra, India	RGB Color space to Lab color space
Narmadha and Arulvadivu (2017)	Narrow brown spot, Brown Spot, and Blast	Internet	RGB Color space to gray scale color space
Archana and Arun (2018)	Brown Spot and Bacterial Leaf Blight	Not mentioned	RGB Color space to HSV color space
Gayathridevi and Neelamegam (2018)	Leaf streak, Leaf blast, False smut, Brown Spot and Bacterial Leaf Blight	Tamil Nadu Rice research Institute, Adu- thurai, Thanjavur, India	Median Filter
Maohua et al. (2018)	Rice blast lesions	Nanjing Agricultural University	RGB Color space to HSV and YCbCr color Space

ISSN: 2233-7857 IJFGCN

Takuya and Yutaka (2018)	Rice blast	Not mentioned	RGB
Ramesh and Vydeki (2018)	Rice blast	Panpoli, Tirunelveli, India	RGB Color space to HSV color space
Taohodul et al. (2018)	Rice blast, Rice bacterial blight, and Rice brown spot	International Rice Research Institute	RGB
bu Bakar et al. (2018)	Rice leaf blast	Malaysian Agricultural Research and Development Institute, Malaysia	Histogram Equalization, RGB to HSV
Komal et al. (2019)	Bacterial Leaf Blight, False Smut, and Brown spot	Rice Research Institute, Lahore, Pakistan	RGB Color space to gray scale color space
Wan-Jie et al. (2019)	Rice Blast	Institute of Plant protection, Jiangsu, China	RGB
Chowdhury et al. (2019)	Brown spot, Neck blast, Bacterial leaf	Bangladesh Rice Research Institute, & Punjab, India	RGB

ISSN: 2233-7857 IJFGCN

	Blight, Sheath Rot, False Smut,Sheath blight, Brown Plant hopper, Stem borer,& Hispa	Bangladesh	
Neha et al. (2019)	Rice blast, Sheath Blight, and Brown Spot	Not Mentioned	Not Mentioned

ISSN: 2233-7857 IJFGCN

Table 2. Review of Different Techniques applied in various image processing phases for plant disease detection

Image Processing Phases	**Reference and Year**	**Objective**	**Methodology**	**Performance Metric**
Image Preprocessing	[15] 2017	Detection of plant disease over cotton Plant	Machine Learning Regression-Median Filtering	Accuracy 83.26
	[16] 2017	Detection of infected and healthy leaf	Image processing-Weiner filtering	Accuracy 80.99
	[17] 2017	Diagnosing plant Disease	Gaussian smooth approach	Accuracy 90.96
Image Segmentation	[18] 2017	Identification of mineral deficiency	Fuzzy C mean and K-Mean Clustering	Accuracy (FCM)= 92%, Accuracy(K-Mean)=85%
	[19] 2017	Cucumber leaf spot disease detection	Fuzzy C mean Average segmentation	error=0.12% and exhibited an efficiency accuracy in the detection of the disease
	[20] 2015	Detection and classification of plant diseases	Image processing	Higher accuracy
	[21] 2018	Rice leaf blast Detection	Color image thresholding	The severity of the disease is adequately classified
Feature Extraction	[22] 2007	Texture Extraction	Image Processing	Accuracy= 88.56%
	[23] 2018	Evaluation of soybean leaf	defoliation Color Extraction	Accuracy= 96%
	[24] 2018	Detection of Leaf Disease Feature extraction-	Edge detection	Accuracy= 82%
Classification	[26] 2018	Rice disease determination	Principal Component Analysis and Neural Network	Accuracy of BP neural network 95.83%
	[32] 2017	Detect the classification of leaf disease	K-Mean Clustering	Accuracy FCM=95% K-Mean=85.05%

ISSN: 2233-7857 IJFGCN

	[34] 2015	Identification of rice panicle	Analysis and Support Vector Machine	Accuracy : Raw Reflectance Spectra 96.55% , First Reflectance Spectra 99.14%, Second Reflectance Spectra 96.55

(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 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' 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 understood that Euclidean separation of the distinct color is proportional to the variation that human visual impact over CIE Lab color space [23].

ISSN: 2233-7857 IJFGCN

(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

ISSN: 2233-7857 IJFGCN

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.

References

[1] Papademetriou, M.K., (2000). Rice production in the Asia-Pacific Region: Issues and perspectives. In 'Bridging the Rice Yield Gap in the Asia-Pacific Region. FAO, UN, Bangkok, Thailand. RAP Publication 2000/16.

[2] Almanac, R., (2013). Source Book for One of the Most Important Economic Activities on Earth, Fourth Edition. [4] Khoenkaw, P.,(2016). An image-processing based algorithm for rice seed germination rate evaluation, 2016 International Computer Science and Engineering Conference (ICSEC), Chiang Mai, 1-5.

[3] Vimal, S.R., Patel, V.K. and Singh, J.S., 2018. Plant growth promoting Curtobacterium albidum strain SRV4: An agriculturally important microbe to alleviate

ISSN: 2233-7857 IJFGCN

salinity stress in paddy plants. Ecological Indicators.
[4]Lurstwut, B., Pornpanomchai, C., 2017. Image analysis based on color, shape and texture for rice seed (RiceL.) germination evaluation. Agriculture and Natural Resources 51, 383-389.
[5]Fang, C., Zhao-yan, L., Yi-bin, Y., 2005 Machine Vision Analysis of Characteristics and Image Information Base Construction for Hybrid Rice Seed.RICE SCIENCE (2005). 12(1), 13-18.
[6]Anthonys, G. and Wickramarachchi, N., 2009. An image recognition system for crop disease identification of paddy fields in Sri Lanka, 2009 International Conference on Industrial and Information Systems (ICIIS), Sri Lanka, 403-407.
[7]Pugoy RADL, Mariano V.Y.2011 Automated rice leaf disease detection using color image analysis. In 3rd international conference on digital image processing, volume 8009. Chengdu: SPIE; F1-F7.
[8] Phadikar, S., and Sil, J., 2008. Rice disease identification using pattern recognition techniques, 2008 11th International Conference on Computer and Information Technology, Khulna, 420-423.
[9]Phadikar, S. and Goswami, J., 2016. Vegetation indices based segmentation for automatic classification of brown spot and blast diseases of rice, 2016 3rd International Conference on Recent Advances in Information Technology (RAIT), Dhanbad, 284-289.
[10]Sengupta, S., & Das, A. K., 2017. Particle Swarm Optimization based incremental classifier design for rice disease prediction.Computers and Electronics in Agriculture, 140, 443–451. https://doi.org/10.1016/j.compag.2017.06.02 4.
[11] Shah, J. P., Prajapati, H. B., & Dabhi,K. (2016). A survey on detection and classification of rice plant diseases. 2016 IEEE International Conference on Current Trends in Advanced Computing (ICCTAC). doi:10.1109/icctac.2016.7567333
[12]D. Groth and L. S. U. Agcenter, “Rice Disease Identification Photo Link”.
[13] “IRRI - Rice science for a better world.” [Online]. Available: http://irri.org/. [Accessed: 20-Nov-2018]. Yao, Q., Chen, G., Wang, Z., Zhang, C., Yang, B., & Tang, J., 2017. Automated detection and identification of white-backed plant hoppers in paddy fields using image processing. Journal of Integrative Agriculture, 16(7), 1547–1557.
[14] Sarangdhar, A.A. and Pawar, V.R., 2017. April. Machine learning regression technique for cotton leaf disease detection and controlling using IoT. In Electronics, Communication and Aerospace Technology (ICECA), 2017 International conference of IEEE. 2, 449-454.
[15] Rewar, E., Singh, B.P., Chhipa, M.K., Sharma, O.P. and Kumari, M., 2017. Detection of Infected and Healthy Part of Leaf Using Image Processing Techniques.
[16]Nti, I.K., Eric, G. and Jonas, Y.S., 2017. Detection of Plant Leaf Disease Employing Image Processing and Gaussian Smoothing Approach. International Journal of Computer Applications, 162(2).
[17]Sethy, Kumar, P., et al. 2017. Identification of Mineral Deficiency in Rice Crop based on SVM in Approach of K- Means & Fuzzy C-Means Clustering. HELIX 7.5 1970-1983.
[18]Bai, X., Li, X., Fu, Z., Lv, X. and Zhang, L., 2017. A fuzzy clustering segmentation method based on neighborhood grayscale information for defining cucumber leaf spot disease images. Computers and Electronics in Agriculture, 136, 157-165.
[19] Rishi, N. and Gill, J.S., 2015. An Overview on Detection and Classification of Plant Diseases in Image Processing. International Journal of Scientific Engineering and Research (IJSER), 3(5).
[20]Sethy, P. K., Negi, B. and Bhoi, N., January 2017. Detection of Healthy and Defected Diseased Leaf of Rice Crop using K- Means ClusteringTechnique. International Journal of

ISSN: 2233-7857 IJFGCN

Computer Applications 157(1) 24- 27.
[21]Sanyal, P., Bhattacharya, U., Parui, S. K., Bandyopadhyay, S. K. and Patel, S., 2007. Color Texture Analysis of Rice Leaves Diagnosing Deficiency in the Balance of Mineral Levels towards Improvement of Crop Productivity, 10th International Conference on Information Technology (ICIT 2007), Orissa, doi: 10.1109/ICIT.2007.40, 85-90.
[22] Liang, W., Kirk, K. R., & Greene,J. K. (2018). Estimation of soybean leaf area, edge, and defoliation using color image analysis. Computers and Electronics in Agriculture, doi:10.1016/j.compag.2018.03.021, 150, 41–51.
[23] Gajanan, D.E., Shankar, G.G. and Keshav, G.V., 2018. Detection of Leaf Disease Using Feature Extraction for Android Based System.
[24] Arivazhagan, S., Shebiah, R.N., Ananthi, S. and Varthini, S.V., 2013. Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features. Agricultural Engineering International: CIGR Journal, 15(1), 211-217.
[25] Xiao, M., Ma, Y., Feng, Z., Deng, Z., Hou, S., Shu, L., & Lu, Z., 2018. Rice blast recognition based on principal component analysis and neural network. Computers and Electronics in Agriculture, doi:10.1016/j.compag.2018.08.028, 154, 482– 490.
[26] Venugoban, K and Ramanan, A., 2014. Image Classification of Paddy Field Insect Pests Using Gradient-Based Features, International Journal of Machine Learning and Computing 4(1), 1-5.
[27] Orillo, J. W., Cruz, J. D., Agapito, L., Satimbre, P. J., & Valenzuela, I., 2014. Identification of Diseases in Rice Plant (Oryza Sativa) using Back Propagation Artificial Neural Network. 7th IEEE International Conference Humanoid, Nanotechnology, Information Technology Communication and Control, Environment and Management (HNICEM) Palawan: IEEE, 1-6.
[28] Lu, Y., Yi, S., Zeng, N., Liu, Y., & Zhang, Y. (2017). Identification of rice diseases using deep convolutional neural networks. Neuro computing, 267, 378–384. doi:10.1016/j.neucom.2017.06.023.
[29] Huang, S., Qi, L., Ma, X., Xue, K., Wang, W., & Zhu, X. (2015). Hyperspectral image analysis based on BoSW model for rice panicle blast grading. Computers and Electronics in Agriculture, 118, 167–178. doi:10.1016/j.compag.2015.08.031.
[30]Bhakta, I., Phadikar, S., & Majumder, K. (2018). Importance of Thermal Features in the Evaluation of Bacterial Blight in Rice Plant. Communications in Computer and Information Science, 300–313.doi:10.1007/978-981-13-1343-1_27
[31]Sethy, P. K., Negi, B. and Bhoi, N., January 2017. Detection of Healthy and Defected Diseased Leaf of Rice Crop using K- Means Clustering Technique. International Journal of Computer Applications 157(1) 24-
27.
[31] Liu, Z. Y., Shi, J. J., Zhang, L. W., & Huang, J. F., 2010. Discrimination of rice panicles by hyperspectral reflectance data based on principal component analysis and support vector classification. Journal of Zhejiang University. Science. B, 11(1), 71-8.
[32] Yao, Q., Guan, Z., Zhou, Y., Tang, J., Hu, Y., Yang, B., 2009. Application of support vector machine for detecting rice diseases using shape and color texture features. In 2009 international conference on engineering computation. Hong Kong: IEEE; 79-83.
[33] Chaudhary, P., Chaudhari, A.K., Cheeran, A.N. and Godara, S., 2012. Color transform based approach for disease spot detection on plant leaf. International Journal of Computer Science and Telecommunications, 3(6), 65-70.

ISSN: 2233-7857 IJFGCN

[34] [34] Abu Bakar MN, Abdullah AH, Abdul Rahim N, Yazid H, Misman SN, Masnan MJ (2018) Rice leaf blast disease detection using multi-level colour image thresholding. J Telecommun Electron Comput Eng (JTEC) 10:1–15
[35] [35]Alex Sherstinsky (2020) Fundamentals of recurrent neural network (RNN) and long short-term memory (LSTM) network. Physica D: Nonlinear Phenomena 401
[36] Archana KS, Arun S (2018) Automatic rice leaf disease segmentation using image processing tech- niques. Int J Eng Technol (UAE)
[37] Bhagyashri SG, Gajanan KB (2017) Computer vision based approach to detect rice leaf diseases using texture and color descriptors. In: International conference on inventive computing and informatics (ICICI)
[38] Capms O, Penn S, Ponce J, Fortsyth D (2019) George Mansion University, 2019. [Online]. Available: https://cs.gmu.edu/~kosecka/cs682/lect-segmentation-part1.pdf
[39] Chowdhury RR, Preetom SA, Eunus Ali M, Mohammad AIK, Sajid HA, Farzana N, Abu W (2019) Identification and recognition of rice diseases and pests using deep convolutional neural networks
[40] Divya S, Rajesh W, Manasi G (2015) A review: color feature extraction methods for content based image retrieval. IJCEM Int J Comput Eng Manag 18(3):9–14
[41] Dorothy R, Joany R, Joseph RR, Santhana SP, Rajendran S (2015) Image enhancement by Histogram equalization. Int Nano Corrosion Sci Eng 2(4):21–30
[42] Duncan AV, Bao-Rong L, Norihiko T (2008) The evolving story of rice evolution. Plant Sci 174(4):394–408 Fatemeh H, Mohammad KS (2017) A survey on classification techniques for opinion mining and senti-
[43] ment analysis. Artif Intell Rev 52:1495–1545
[44] Gayathridevi T, Neelamegam P (2018) Image processing based rice plant leaves diseases in Thanjavur, Tamilnadu. Cluster Comput 1–14
[45] Ghassan Mahmoud HA, Ahmed Mohamed A (2015) Edge detection methods. In: 2nd World symposium on Web applications and networking (WSWAN), Sousse
[46] Gonzalez Fernandez I, Iglesias-otero MA, Esteki M, Moldes OA, Mejuto JC, Simal Gandara J (2019) A critical review on the use of artificial neural networks in olive oil production, characterization and authentication. Crit Rev Food Sci Nutr 59(12):104
[47] Gramene. [Online]. Available: https://archive.gramene.org/species/oryza/rice_intro.html
[48] Humeau H, Anne (2019) Texture feature extraction methods: a survey. IEEE Access 7:8975–9001
[49] Huy MD (2019) "kaggle," [Online]. Available: https://www.kaggle.com/minhhuy2810/rice-diseases- image-dataset
[50] Komal B, Mehwish B, Mariam R (2019) Detection and classification of rice diseases: an automated approach using textural features. Mehran Univ Res J Eng Technol 38:239–250
[51] Libo L, Guomin Z (2009) Extraction of the rice leaf disease image based on BP neural network. In: International conference on computational intelligence and software engineering
[52] Lu Y, Yi S, Zeng N, Liu Y, Zhang Y (2017) Identification of rice diseases using deep convolutional neu- ral networks. Neurocomputing 267
[53] Maohua X, You M, Zhixiang F, Ziang D, Shishuang H, Lei S (2018) Rice blast recognition based on principal component analysis and neural network. Comput Electron Agric 154:482–490

ISSN: 2233-7857 IJFGCN

[54] Mehwish R, Muhammad S, Mudassar R (2014) Image compression: a survey. Res J Appl Sci Eng Tech- nol 7(4):656–672
[55] Narmadha RP, Arulvadivu G (2017) Disease symptoms identification in paddy leaf using image process- ing. Adv Comput Sci Technol 10:2213–2223
[56] Neha M, Priyanka BR, Soumya GH, Pooja R (2019) Paddy leaf disease detection using image processing and machine learning. Int J Innov Res Electr Electron Instrum Control Eng 7(2)
[57] Ning C, Wenjing L, Ruizhen B, An C (2017) Application of computational intelligence technologies in emergency management: a literature review. Artif Intell Rev 52(3):2131–2168
[58] Orillo JW, Dela Cruz J, Agapito L, Satimbre PJ, Valenzuela I (2014) Identification of diseases in rice plant (Oryza sativa) using back propagation artificial neural network. In: IEEE international confer- ence humanoid, nanotechnology, information technology communication and control, environment and management (HNICEM), Palawan, Philippines
[59] Pankaj Kumar (2014) Image enhancement using histogram equalization and histogram specification on different color spaces, Rourkela
[60] Phadikar S, Sil J (2008) Rice disease identification using pattern recognition techniques. In: Interna- tional conference on computer and information technology
[61] Prajapati HB, Shah J, Dabhi V (2017) Detection and classification of rice plant diseases. Intell Decis Technol 11:357–373
[62] Ramesh S, Vydeki D (2018) Rice blast disease detection and classification using machine learning algo- rithm. In: International conference on micro-electronics and telecommunication engineering
[63] Rana A, Rawat AS, Bijalwan A, Bahuguna H (2018) Application of multi layer (perceptron) artifi- cial neural network in the diagnosis system: a systematic review. In: International conference on research in intelligent and computing in engineering (RICE), San Salvador
[64] Rice Knowledge Bank. International Rice Research Institute, [Online]. Available: http://www.knowl edgebank.irri.org/training/fact-sheets/pest-management/diseases
[65] Sano Y, Sano R, Morishima H (1984) Neighbour effects between two co-occurring rice species, Oryza sativa and O. glaberrima. J Appl Ecol 21(1):245–254
[66] Sanyal P, Patel SC (2008) Pattern recognition method to detect two diseases in rice plants. Imag Sci J 56:319–325
[67] Shah JP (2019) UCI Machine Learning Repository, 04 2019. [Online]. Available: http://archive.ics.uci. edu/ml/datasets/Rice+Leaf+Diseases
[68] Shakeel A, Abdul H, Khushal K, Isfahan T, Mehboob A, Faisal S (2019) Evaluation of synergistic effect of nanoparticles with antibiotics against enteric pathogens. Appl Nanosci
[69] Shakeel A, Isfahan T, Kashif SH, Khushal K, Muhammad S, Mehboob A, Faisal S (2019b) Synthesis of silver nanoparticles using leaves of Catharanthus roseus and their antimicrobial activity. Appl Nanosci, DEC
[70] Sparks A. "irri.org," [Online]. Available: http://www.knowledgebank.irri.org/step-by-step-production/ growth/pests-and-diseases/diseases
[71] Suganya Devi K, Vaishnave MP, Srinivasan P, Arulperumjothi G (2019) Detection and classification of groundnut leaf diseases using KNN classifier. In: 2019 IEEE international conference on system, computation, automation and networking (ICSCAN)

ISSN: 2233-7857 IJFGCN

[72] Sujung K, Wook-joong K, Seong-Dae K (2008) Automatic white balance based on adaptive feature selection with standard illuminants. In: 5th IEEE international conference on image processing, San Diego
[73] Takuya K, Yutaka H (2018) Development of classification system of rice disease using artificial intel- ligence. In: IEEE international conference on systems, man, and cybernetics (SMC)
[74] Taohodul I, Manish S, Sudipto B, Rudra R (2018) A faster technique on rice disease detectionusing image processing of affected area in agro-field. In: International conference on inventive communi- cation and computational technologies (ICICCT 2018)
[75] Thao N, EUn Ae P, Jiho H, Dong Chul P, Soo Young M (2013) Object detection using scale invarinat feature transform. In: Genetic and evolutionary computing, Prague, Springer, pp 65–72
[76] Vaibhav (2015). [Online]. Available: http://computervisionwithvaibhav.blogspot.com/2015/10/otsu-thres holding.html
[77] Wan-Jie L, Hong Z, Gu-feng Z, Hong-XIn C (2019) Rice blast disease recognition using a deep convolu- tional neural network. Sci Rep 9
[78] Yao Q, Guan Z, Zhou Y, Tang J, Hu Y, Yang B (2009) Application of support vector machine for detect- ing rice diseases using shape and color texture features. In: International conference on engineering computation
[79] Zahid I, Muhammad AK, Muhammad S, Jamal HS, Muhammad HU, Kashif J (2018) An automated detec- tion and

ISSN: 2233-7857 IJFGCN