Logistic Regression and Decision Tree. The accuracy of disease detection achieved from this model was 97% after 10-fold cross-validation. In this paper, attributes (features) were extracted using a correlation-based feature selection method.

[Bakar, *et al.* (2018)] proposed a system to detect Rice Leaf Blast disease, and it also classifies the severity of disease into three different stages like infection, spreading, and worst stage. In this work, the HSV color space is used. Multi-Level thresholding technique applied to find the region of interest. Shape and Color features extracted. This model is not suitable for the identification of other diseases that may have identical traits.

[Ramesh, and Vydeki, (2018)] proposed a system that presents a machine learning technique used for early detection of Rice Leaf Blast disease. K-means clustering algorithm used to separate damaged portion from the healthy portion of the image. Statistical and texture features are used to distinguish healthy and disease-affected leaves. ANN algorithm used for the classification of infected and healthy leaf images.

[Zhang, *et al.* (2018)] proposed a system to detect three types of rice blast lesion namely acute type, chronic type, and white type respectively. Otsu's method used for segmentation. Color, and morphology features are used for classification. SVM classifier with Radial Basis Function (RBF) is used for the classification of three types of rice blast lesion. The average accuracy of classification achieved is 95.6% after 5 fold cross-validation. The segmentation algorithm and feature extraction techniques used in this work may also use for identical crops.

[Islam, *et al.* (2018)] proposed a method to detect and classify the types of disease such as Rice Leaf Blast, Brown spot, and Bacterial blight. It uses a percentage of RGB value as an input for classification using Naive Bayes classifier into different types of diseases. It does not specify any segmentation technique. The accuracy of this model is above 89% for Rice blast disease and above 90% for Bacterial Blight, and Rice Brown Spot disease.

[Prajapati, *et al.* (2017)] proposed a system for the identification of Bacterial blight, Brown spot, and Leaf Smut. K-means clustering algorithm applied for the segmentation and enhanced output of segmentation by eliminating green pixels from the damaged region. Color, shape, and texture features are used as input for classification by the Support Vector Machine. The accuracy achieved is 93.33% on training and 73.33% on test datasets. They achieved 83.80% and 88.57% accuracy, after 5 and 10-fold cross-validations, respectively.

[Pinki, *et al.* (2017)] proposed a system for recognition of Bacterial Blight, Rice Leaf Blast, and Brown Spot diseases. It also gives advice to farmers for the use of pesticides and fertilizers. K-means clustering algorithm used to separate diseased regions from the healthy region of the image. Color, shape, and texture features are used as input for classification by the SVM. It also calculates the severity of the disease by determining the percentage of the damaged portion.

[Narmadha, *et al.* (2017)] purpose of this work is to detect and identify Rice Blast, Brown spot, and Narrow Brown spot diseases using image processing techniques. K-means clustering used to separate unwanted portions and noise from the image, and it detects diseases. It uses shape and color features for classification using ANN and Fuzzy Classification. In this work, accuracy not specified.

[Ghyar, and Birajdar, (2017)] present a system for automatic detection of Rice Leaf Blast, and Brown Spot disease using texture and color descriptors. Three features like area, texture descriptors, and color moments are considered for classification. Features are selected using a genetic algorithm. SVM and ANN classifiers are used in this system. SVM provides 92.5% accuracy and ANN provides 87.5% accuracy.

[Joshi, and Jadhav, (2016)] presents a system for the detection of Rice Leaf Blast, Bacterial Blight, Brown Spot, and Sheath Rot. Color and shape features were used for classification. Two classifiers, K-NN and MDC (Minimum Distance Classifier) used in this system. K-NN achieved 87.02 % accuracy and MDC achieved 89.23% classification accuracy.

[Chung, *et al.* (2016)] proposed a system to classify unhealthy and healthy seedlings. 3-week old seedlings used for this work. The seedlings were prepared in an incubator for 3 weeks. Using a flatbed scanner, images of infected seedlings were scanned. The thresholding technique used for segmentation. Essential traits and parameters are used as input to the SVM classifiers. A support vector machine (SVM) used as a classifier for differentiating infected seedlings from healthy seedlings. Two classifiers used in a cascade manner for classification. Parameters selected using a genetic algorithm. In this work, an accuracy achieved is 87.9%.

[William, *et al.* (2014)] proposed a system to detect rice disease more accurately by using image processing and the Artificial Neural Network algorithm. Back Propagation neural network used for disease identification and increase the accuracy, and the performance of the image-processing algorithm. It also suggests a recommendation for quick relief and tactical planning for the next plantation. Otsu's method is used for the segmentation. Features such as area, mean, and standard deviation extracted and used for the classification. Back-propagation Neural Network algorithm is used. Accuracy was 100%.

[Asfarian, *et al.* (2013)] proposed a system to identify four rice diseases namely Rice Leaf Blast, Brown spot, Bacterial leaf blight, and tungro. It uses fractal descriptors to study the texture of the lesions. Diseased images extracted manually and used as input for the identification of disease. The descriptors of lesion images are used for classification as input using probabilistic neural networks. This approach achieved 83% disease identification accuracy.

[Phadikar, *et al.* (2013)] purpose of this research work is to identify Rice Leaf Blast, Brown Spot, Bacterial blight, and Sheath rot. Fermi energy technique applied to separate the diseased region. Genetic Algorithm applied to find the infected region. Using a novel techniques color, shape, and position features extracted and used for the classification of diseases. Important features are selected to diminish the intricacy of the classifier using rough set theory (RST). A rule-based technique used for classifying the diseases.

[Phadikar, *et al.* (2012)] proposed a system used for detecting Rice Leaf blast, and Rice brown spot using a morphological change in a leaf. The radial distribution features used as an input for the classification. Bayes and SVM used for the classification. Bayes achieved an accuracy of 79.5% and SVM achieved 68.1%. Preprocessing of images required before classification and detection.

4. Summary of Image Processing Techniques used in Rice Disease Detection

In this section, we present different image processing techniques implemented in research works on rice disease identification by the researchers. We used a total of 21 research papers of the last eight years on rice leaf and seedling disease by considering parameters such as segmentation type, segmentation techniques, features extracted, dataset size, and image background. Table-1. Presents summary of different image processing techniques used in rice disease detection.

Table 1. Summary of Image Processing Techniques Used in Rice Disease Detection

Ref.	Segmentation Type	Techniques used	Extracted features	Size of dataset
[21]	Thresholding	Otsu's Method	Texture Features(LBP)	120 images
[29]	Watershed	Distance transformation	Texture and Shape	2000 microscopic images
[10]	Clustering and Thresholding	K-means and Otsu method	Shape and Color	500 sample images
[16]	Clustering	K-means	size, color, proximity, and centroids	Not specified.
[30]	Clustering and Thresholding	K-means and Otsu method	Texture, color , and shape	3010 images
[24]	Thresholding	Otsu's Method	Texture and Wavelets	Not specified
[9]	Not Specified	Not Specified	Correlation Based Feature	480 images
[2]	Multi-Level Thresholding	Pixel-based	Shape and Color	Not Specified
[22]	Clustering	K-means	Statistical and Texture	300 images
[31]	Thresholding	Otsu's Method	Morphology and color	90 images
[7]	Not Specified	Not Specified	RGB values	60 images
[19]	Clustering	K-means	Color, shape, and texture	Not specified.
[20]	Clustering	K-means	Color, texture, and shape	Not specified
[15]	Clustering	K-means	Shape and color	Not specified
[5]	Clustering	K-means	Area , texture descriptors using GLCM , and color moments	Not specified
[8]	Clustering	YCbCr color space	Shape and Color	115 images
[3]	Thresholding	--	Morphological and color traits	700 images
[28]	Thresholding	Otsu's Method	Statistical features and fraction(area)	134 images
[1]	Fractal Descriptors	Multiscale transform	Color	40 images
[17]	Thresholding and Clustering	K-means, Otsu method, and Fermi energy based	Color, shape and position	500 images
[18]	Thresholding	Otsu's method	Radial hue distribution	1000 images

5. Summary of Machine Learning Operations used in Rice Disease Detection and Classification

This section presents a survey of different machine learning [Tom, (1997)] algorithms applied to rice disease detection and classification. In this survey, we considered the following parameters like the author's name, and publication year, category of disease, techniques used, detection/classification accuracy, limitations, and future scope of their research work. Table-2. Presents the summary of various machine learning [Tom, (1997)] operations used in rice diseases detection and classification.

Table 2. Summary of Various Machine-Learning Operations Used in Rice Disease Detection and Classification

Author's name	**Year of the publication**	**Types of Diseases**	**Applied Technique /Algorithm**	**Detection/ Classification Accuracy**	**Limitations/ Future Scopes**
Pothen Minu Eliz et al. [21]	(2020)	Bacterial blight, Leaf Smut and Brown Spot	SVM	94.6%	1. Only three diseases are considered. 2. Database extension needed in order to reach more accuracy.
Yang Ning et al.[29]	(2019)	Rice Smut, and Rice Blast	DT	94%	1. Obtaining a microscopic image and microscopic image acquisition is difficult and complicated. 2. It is used to detect only two types of diseases. 3. Accuracy is less (94%).
Larijani Mohammad Reza et al. [10]	(2019)	Rice Blast	KNN	94%	1. It is used only to detect Rice Blast Disease. 2. No comparison with other classifier
Nidhis A. D. et al. [16]	(2019)	Rice Blast, Brown Spot, and Bacterial Blight	k-means clustering	Not specified	1. Accuracy is not specified. 2. Dataset size is not specified. 3. Only three diseases are covered.
Zhou Guoxiong et al. [30]	(2019)	Rice blast, Sheath blight, and Bacterial blight	R-CNN	97.2%	1. It is not suitable for monitoring large-scale rice farming. 2. Complexity is more.
Shreekanth K. N. et al. [24]	(2019)	Leaf Blast, Brown Spot and Leaf Blight	Feed forward NN	83.3% for three and 100% for two types of diseases.	1. Size of dataset is not specified. 2. Success rate is low for dataset of three types of diseases. 3. Only three diseases are covered.
Kawcher Ahmed et al. [9]	(2019)	Bacterial Blight, Leaf Smut , and Brown Spot	K-NN, DT, Naive Bayes and Logistic Regression	97%	1. It predicted the rice leaf diseases with greater or lesser accuracy. 2. Quality of datasets can be improved. 3. Need to analyze the performance of learning methods.
Bakar Abu M.N. et al. [2]	(2018)	Rice Blast	Multi-Level Thresholding	Not specified	1. Only one Rice disease is covered. 2. The technique is not suitable for detection of other diseases which may have similar features.
Ramesh S. et al. [22]	(2018)	Rice Blast	ANN	90% for the infected images and 86% for the healthy images	1. It used only for detecting Rice Blast Disease. 2. It distinguishes only the healthy and unhealthy leaves. 3. It will not classify types of diseases.
Zhang Jun. et al. [31]	(2018)	Rice Blast	SVM	95.6%	1. Very small dataset is used 2. No comparison with other classifier
Islam Taohidul et al. [7]	(2018)	Rice Blast, Brown Spot, and Bacterial Blight	Naïve Bayes	Rice Blast above 89%, Brown Spot above 90%, and Bacterial Blight above 90%	1. Dataset is very small. 2. Segmentation is not used. 3. Only RGB value features is used.
Prajapati H. B. et al. [19]	(2017)	Bacterial Blight, Brown Spot, and Leaf Smut	SVM	Training accuracy 93.33% , and testing accuracy 73.33% .	1. Testing accuracy is very less. 2. Very large set of features are used.
Pinki F. T. et al. [20]	(2017)	Leaf blast, Bacterial blight and Brown spot	SVM	Not specified	1. Accuracy is not specified.
Narmadha R. P. et al. [15]	(2017)	Rice Blast, Narrow Brown Spot, and Brown Spot.	ANN and Fuzzy Classification	Not specified	1. Accuracy is not specified. 2. Only three diseases are covered. 3. Implementation details and Classification of diseases is not properly explained. 4. Dataset is not specified.
Ghyar Bhagyashri S. et al. [5]	(2017)	Leaf Blast and Brown Spot	ANN and SVM	Not specified	1. Only two diseases are covered.

Joshi Amrita A. et al. [8]	(2016)	Rice Blast, Bacterial Blight, Brown spot, and Sheath rot	k-NN and MDC	K-NN accuracy 87.02 % and MDC accuracy 89.23%	1. Dataset is very small. 2. Segmentation is not properly mentioned. 3. More diseases can be covered.
Chung Chia-Lin et al. [3]	(2016)	Bakanae	SVM	87.9%	1. This approach is less subjective and time-consuming. 3. Accuracy is less. 4. Complexity is more.
William John et al. [28]	(2014)	Bacterial Leaf Blight, Brown Spot, and Rice Blast	Back Propagation NN	100%	1. Only three diseases are covered. 2. Dataset size is small. 3. No performance comparison with other Neural Network. 4. Computational cost is high.
Asfarian Auzi et al. [1]	(2013)	Leaf Blast, Brown Spot, Bacterial Blight, and Tungro	Texture Analysis and PNN	83%	1. Dataset is very small. 2. Accuracy can be improved.
Phadikar Santanu et al. [17]	(2013)	Rice blast, Brown spot, Bacterial blight, and Sheath rot	Rule generation	90%	1. Computational complexity is more. 2. Accuracy can be improved.
Phadikar Santanu et al. [18]	(2012)	Brown spot and rice blast	Naïve Bayes and SVM	79.5% for Bayes and 68.1% for SVM	1. Accuracy is very low. 2. Only two diseases are considered. 2. Comparison between classifier not mentioned clearly.

6. Conclusion

Rice is a major crop in India. Rice plant diseases are very difficult to detect and classify by the naked eye by the farmers and product producers. Therefore, an automatic detection system is a modern approach.

In this work, we present a survey of different approaches and techniques applied for the identification and classification of rice leaf and seedling diseases. A total of 21 papers of the last eight years from 2012 to 2020 are considered on rice plant diseases for doing surveys.

In the survey paper, we found that various segmentation techniques such as k-means clustering, Otsu's method, Pixel-based, Fermi Energy, Fractal Descriptors and watershed method are used and statistical, color, shape, texture, wavelets, size, area, proximity, and centroids, morphology features, correlation-based feature, textural descriptors, and color moments features are extracted.

Following Machine Learning Algorithms used in survey papers: ANN, Genetic Algorithm, SVM, Decision Tree, K-NN, R-CNN, Feed-Forward Neural Network, Naïve Bayes, Logistic Regression, Minimum Distance Classifier (MDC), Back Propagation Neural Network, Rule generation technique, Texture Analysis, and Probabilistic Neural Network (PNN). Many authors used the SVM classifier for the classification of diseases when compared with other classifiers. We concluded that SVM and ANN give better accuracy, for the classification of diseases.

References

[1] Asfarian, A.; Herdiyeni, Y.; Rauf, A.; Mutaqin, K. H. (2013): Paddy Diseases Identification with Texture Analysis using Fractal Descriptors Based on Fourier Spectrum. IEEE International Conference on Computer, Control, Informatics and Its Applications.

[2] Bakar, Abu M. N.; Abdullah, A.H.; Rahim, A. N.; Yazid, H.; Misman, S. N.; Masnan, M. J. (2018): Rice Leaf Blast Disease Detection Using Multi-Level Colour Image Thresholding. Journal of Telecommunication, Electronic and Computer Engineering (JTEC). 10(1-15), 1-6.

[3] Chung, C.; Huang, K.; Chen, S.; Lai, M.; Chen, Y.; Kuo, Y. (2016): Detecting Bakanae disease in rice seedlings by machine vision. Computers and Electronics in Agriculture. vol. 121, pp. 404-411.

[4] Diego, I. P.; Rafael, R. (2018): Computer vision and artificial intelligence in precision agriculture for grain crops: A systematic review. Computers and Electronics in Agriculture. 153:69-81.

[5] Ghyar, B. S.; Birajdar, G. K. (2017): Computer vision based on approach to detect rice diseases using texture and color descriptors. IEEE International Conference on Inventive Computing and Informatics (ICICI). Part Number: CFP17L34-ART, ISBN: 978-1-5386-4031-9.

[6] Groth D. and Agcenter L.S.U. Rice Disease Identification Photo Link.

[7] Islam, T.; Sah, M.; Baral, S.; Roychoudhury, R. (2018): A Faster Technique on Rice Disease Detection Using Image Processing of Affected Area In Agro-Field. IEEE International Conference on Inventive Communication and Computational Technologies (ICICCT).

[8] Joshi, A. A.; Jadhav, B. (2016): Monitoring and controlling rice diseases using image processing techniques. IEEE International Conference on Computing, Analytics and Security Trends (CAST). pp.471–476.

[9] Kawcher, A.; Shahidi, T.; Syed, Md. I. A.; Sifat, M. (2019): Rice Leaf Disease Detection Using Machine Learning Techniques. IEEE International Conference on Sustainable Technologies for Industry 4.0 (STI). 24-25.

[10] Larijani M. R. , Ardeh E. A. A., Kozegar E. and Loni R. 2019. Evaluation of image processing technique in identifying rice blast disease in field conditions based on KNN algorithm improvement by K-means. Food Science & Nutrition. published by Wiley Periodicals, Inc. Available: 10.1002/fsn3.1251.
[11] Malathi, K.; Nedunchelian, R. (2017): A recursive support vector machine (RSVM) algorithm to detect and classify diabetic retinopathy in fundus retina images. Biomedical Research. Volume Special Issue, pp.1 – 8 ISSN 0970-938X.
[12] Narmadha, R. P.; Arulvadivu, G. (2017): Detection and Measurement of Paddy Leaf Disease Symptoms using Image Processing. IEEE International Conference on Computer Communication and Informatics (ICCCI -2017).
[13] Nidhis, A. D.; Pardhu, C. N. V.; Reddy, K. C.; Deepa, K. (2019): Cluster Based Paddy Leaf Disease Detection, Classification and Diagnosis in Crop Health Monitoring Unit. Lecture Notes in Computational Vision and Biomechanics. Springer Nature, Switzerland AG.
[14] Phadikar, S.; Sil, J.; Das, A. K. (2013): Rice diseases classification using feature selection and rule generation techniques. Computers and Electronics in Agriculture . 90, pp.76–85.
[15] Phadikar, S.; Sil, J.; Das, A.K. (2012): Classification of Rice Leaf Diseases Based on Morphological Changes. International Journal of Information and Electronics Engineering . 2(3), pp.460-463.
[16] Prajapati, H. B.; Shah, J. P.; Dabhi, V. K. (2017): Detection and classification of rice plant diseases. Intelligent Decision Technologies. 11(3), 357–373.
[17] Pinki, F. T.; Khatun, N.; Islam, S. M. M. (2017): Content based Paddy Leaf Disease Recognition and Remedy Prediction using Support Vector Machine. IEEE International Conference of Computer and Information Technology (ICCIT). 22-24, December.
[18] Pothen, M. E.; Pai, M. L. (2020): Detection of Rice Leaf Diseases Using Image Processing. IEEE International Conference on Computing Methodologies and Communication (ICCMC 2020). 978-1-7281-4889-2/20.
[19] Ramesh, S.; Vydeki, D. (2018): Rice Blast Disease Detection and Classification using Machine Learning Algorithm. IEEE International Conference on Micro-Electronics and Telecommunication Engineering.
[20] Rafael, C. G.; Richard, E. (1997): Digital Image Processing. Pearson Education, Third Edition.
[21] Shreekanth, K. N.; Suresha, M.; Naik, H. (2019): A Novel Segmentation and Identification of Diseases in Paddy Leaves Using Color Image Fusion Technique. IEEE International Conference on Image Information Processing (ICIIP). 978-1-7281-0899-5.
[22] Shah, J. P.; Prajapati, H. B.; Dabhi, V. K. (2016): Survey on Detection and Classification of Rice Plant Diseases. IEEE conference on Current Trends in Advanced Computing (ICCTAC). pp.1-8.
[23] Singh, A.K.; Rubiya, A.; Raja, B. S. (2015): Classification of rice disease using digital image processing and svm classifier. International Journal of Electrical and Electronics Engineers. 7(1): 294-299.
[24] Tom M. Mitchell., (1998): Machine Learning. McGraw-Hill Publication. ISBN: 0070428077.
[25] William, J.; Jennifer, D. C.; Leobelle, A.; Paul, J. S.; Valenzuela, I. (2014): Identification of Diseases in Rice Plant (Oryza Sativa) using Back Propagation Artificial Neural Network. IEEE International Conference on HNICEM, pp.12-16.
[26] Yang, N.; Qian, Y.; Mesery, S. E.; Zhang, R.; Wang, A.; Tang, J. (2019): Rapid detection of rice disease using microscopy image. Journal Sci. Food Agri. Published online in Wiley Online Library.
[27] Zhou, G.; Zhang, W.; Chen, A.; He, M. (2019): Rapid Detection of Rice Disease Based on FCM-KM and Faster R-CNN Fusion. IEEE Access. Vol. 7, pp. 143190 – 143206.
[28] Zhang, J.; Yan, L.; Hou, J. (2018): Recognition of rice leaf diseases based on salient characteristics. IEEE World Congress on Intelligent Control and Automation.

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