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# An Overview of Machine Learning Methods for the Detection of Diseases in Rice Plants in Agricultural Research

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ABSTRACT

In order to mitigate decreases in agricultural yield and production, the identification of diseases in plants assumes paramount importance. The agricultural sector has been employing various methodologies rooted in machine learning and image processing to address these challenges. This comprehensive analysis focuses specifically on the detection of diseases in rice plants by leveraging a diverse array of machine learning and image processing techniques with input images of infected rice plants. Furthermore, we delve into significant concepts pertaining to machine learning and image processing that aid in the identification and categorization of plant diseases. Various classification methods such as the k-Nearest Neighbor Classifier (KNN), Support Vector Machine (SVM), Probabilistic Neural Network (PNN), Genetic Algorithm (GA), and others find applications in agricultural research endeavors. The selection of an appropriate classification method assumes critical importance as the quality of the output is contingent on the input data. The classification of plant leaf diseases finds utility across multiple domains, including agriculture and biological research. This paper presents an extensive exploration of rice plant diseases, encompassing aspects such as image dataset size, preprocessing techniques, segmentation methods, and classifiers.

Keywords : Classification, Machine learning, Rice plant diseases, Segmentation

## I. INTRODUCTION

Agriculture serves as the primary source of income in many countries worldwide. Given its immense significance, farmers carefully choose their crops, fields, and associated pesticides to accelerate plant growth [1]. Rice stands as the predominant food crop in several nations [2]. However, the agricultural sector faces critical challenges due to diseases that adversely affect the quantity and quality of rice harvests. The lower production rates can be attributed to factors such as limited knowledge of fertilizer management, insufficient awareness of diseases and pests, and a scarcity of agricultural experts [3].

Plant diseases have both direct and indirect implications for environmental problems. As these diseases spread globally, they impair overall plant function and negatively impact the economy by significantly reducing crop yields [4]. Plants are susceptible to numerous bacterial and fungal diseases [5]. In the case of rice plants, several diseases affect them, including Brown spot, Sheath blight, and NBSD Leaf blast [6]. The severity of the disease can be observed through the damage caused by the blast. Another notable rice disease, brown spot, is transmitted by the fungus Bipolaris Oryza and typically manifests throughout the growing season, particularly in silicon-deficient soils [7]. Rice diseases account for a loss of 10 to 15 percent of production in Asia [8]. Traditional methods of analyzing and monitoring plant diseases rely on manual efforts, demanding significant time and resources [9]. Farmers sometimes encounter difficulties in identifying diseases that lead to crop loss. An effective solution for farmers is the automated processing of captured images of infected leaves, enabling prompt disease recognition. Early disease detection is crucial as it prevents prolonged disease progression, which can hinder plant productivity.

For diagnosing rice plant diseases, various image processing and machine learning algorithms have been developed. The accuracy of machine learning-based plant disease identification relies on three key processes: feature segmentation, feature extraction, and classification algorithms. Deep learning methodologies have shown promising results in image classification, with researchers studying diseases in mango [11], apple [12], tomato [13], rice [14], and wheat [15]. In many cases, leaves or fruits have been used in images for disease detection, often with uniform backgrounds. The photographs are captured in paddy fields, and the infected portions of the leaves are segmented and pre-processed. Features are then extracted from the segmented images, and machine learning techniques are employed for disease classification. The system's ability to accurately perform image processing and machine learning operations is critical for its success [16].

## General Structure

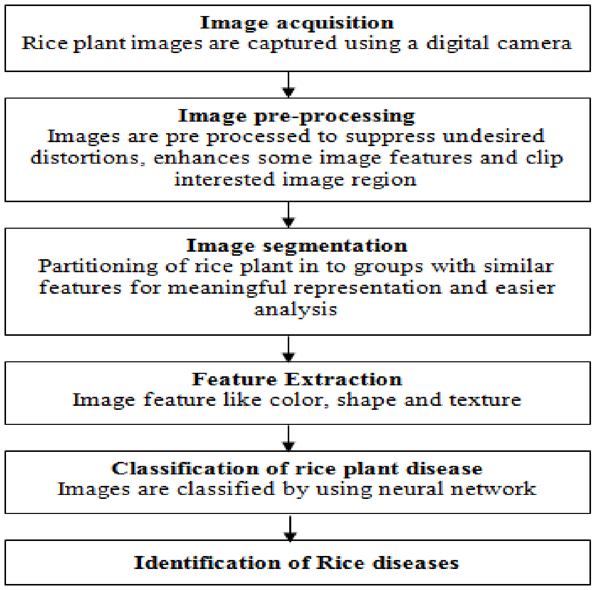



Figure 1 depicts the procedures used to identify the rice disease

The classification and identification of rice plant diseases involve several steps as outlined below:

1. Image segmentation: This step involves dividing the preprocessed images into groups with similar features, making it easier to analyze them.
2. Feature extraction: In this process, features are extracted from the segmented images based on shapes, colors, and textures. These extracted features provide valuable information for disease identification.
3. Classification: The classification process aims to categorize the different types of rice plant diseases based on the extracted features. Machine learning algorithms and techniques are commonly employed for this purpose.

Pre-processing plays a crucial role in improving the captured image features, enhancing the subsequent data processing steps. Figure 1 illustrates the procedures employed in the identification of rice diseases.

## II. LITERATURE REVIEW

| Author Name | Key Technique | Description | Limitations |
|---|---|---|---|
| Santanu Phadikar et al [17] | Segmentation | To identify the infected leaf regions in rice plant images, a region identification approach based on Fermi energy was proposed. Textural features focused on NGLDM (Neighboring Gray-Leveled Dependence Matrix) were extracted to classify the different diseases affecting rice plants. | The accuracy of segmentation is low. |
| C.Kumar Charliepaul [18] | Feature Extraction | The symptoms were characterized by analyzing features such as the color and shape of the infected parts of the rice plant. These extracted features were then utilized to recognize and identify the specific diseases affecting the rice plants. | The risk factors associated with the identified diseases were not discovered. |
| Amit | Classification | A methodology was proposed to recognize the most prevalent disease in rice plants, namely Rice Leaf Blast (RLB), using an SVM (Support Vector Machine) classifier. | The segmentation process was not improved and the conventional framework for segmentation was employed. |

## III. METHODS AND MATERIAL

### 2.1 Diagnosis of Rice Diseases using different methods

Manoj Mukherjee et al. introduced a framework for mitigating the impact of rice plant diseases by processing images of paddy leaves using histograms. This framework enables early identification of diseases and facilitates prompt actions to minimize production losses. The process involved capturing leaf images, converting them to grayscale, and generating histograms using MATLAB functions. These images served as the basis for disease classification and grading. Additionally, a consultative disease treatment unit was established with the support of agricultural experts to provide guidance based on disease detection and stage.

In a similar vein, Mittal, Namita et al. proposed a framework for icon-centric information retrieval to assist digitally illiterate farmers in accessing information effectively from the Internet. By leveraging pattern recognition and digital image processing, farmers were able to swiftly identify diseases, their causes, and symptoms without relying on experts visiting their farms. The efficacy of this approach was demonstrated through practical outcomes, where 25 images were trained for each disease category and displayed in the image processing section. The results can be further enhanced by increasing the number of images used to train the system.

## COMPARATIVE ANALYSIS

Gayathri and Neelamegam [22] proposed a framework utilizing image processing techniques for automated identification of leaf diseases. The framework involved pre-processing, image acquisition, segmentation, and paddy leaf disease classification. To extract the features, a hybrid approach combining Discrete Wavelet Transform (DWT), Gray Level Co-occurrence Matrix (GLCM), and scale-invariant feature transform methodologies was employed. These extracted features were then fed into various classifiers, including Naive Bayesian, multiclass SVM, neural network (NN), backpropagation, K-Nearest Neighbors (KNN), and neural network (NN). Multiple classification methods were explored for leaf disease classification, and the results showed that the multi-class SVM outperformed other classifiers with an accuracy of 98.63 percent or higher.

Khaing and Chit Su [23] proposed an automated classification system for four types of paddy diseases: leaf streak, bacterial leaf blight (BLB), brown spots on leaves, and Rice Leaf Blast (RLB), caused by fungal and bacterial diseases. The system involved preprocessing, image acquisition, leaf checking, classification, and feature extraction. Color, statistical, and textural features such as standard deviation, mean, contrast, energy, entropy, and correlation were extracted from the images using Principal Component Analysis (PCA), GLCM, and Color Grid-based Moment techniques. The SVM classifier was utilized for disease categorization. The method achieved a performance of 72.70% for the original grayscale conversion and 90% for the modified grayscale conversion. In Table 3, various machine learning (ML) and image processing strategies employed in the detection and classification of rice diseases are compared and explained.

Table 3: Comparison of Various approaches used in rice diseases diagnosis

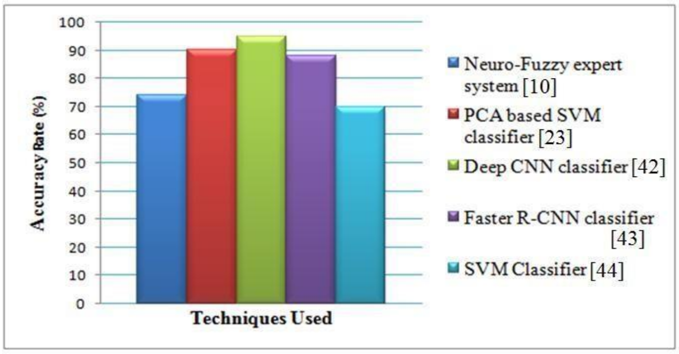
| AuthorName | Technique Used | Disease Identified | Accuracy | Merits | Demerits |
|---|---|---|---|---|---|
| Mohd adzhar abdul kahar *etal* [10] | Neuro-Fuzzy expert system | LBD, BSD, BLB | 74.21%. | Recognized the diseases at their early stages. | Issues in tackling the noises and other lighting problems due to external forces. |
| Khaing War Htun, and Chit Su Htwe[23] | PCA, Color Grid-centered Moment and GLCM for feature extortion and SVM for classification | Leaf blast, leaf streak, BLB, leaf brown spot | 90% | Attained Highest accuracy | This methodology was not applicable for categorization of crop diseases |
| Chowdhury Rafeed Rahman *et al*[42] | Deep CNN-centered classification | pests and diseases in rice plants were recognized | 95% | Accurately and timely detect the diseases | Deep learning methodology contained several layers for classification. So it took more time to spot the diseases contrasted with others |

| | | | | | |
|---|---|---|---|---|---|
| M. Akila and P. Deepan[43] | R-FNN, R- CNN, SSD | Diseases and pests of various plants were identified | 88% | Ability to compete with complex scenarios and effectively identifies disparate diseases. | Time Consuming |
| Suman T1, Dhruvakumar T2 [44] | SVM classifier | rice blast diseases, narrow brown spot, BLB, brown spot, | 70% | Efficiently classified 4 kinds of diseases in rice | Lowest accuracy when contrasted with others |
| Fahrul Agus *et al* [45] | ESforRPD2 application, Unified Modelling Language and Waterfall Paradigm | 8 sorts of diseases and 48 symptoms of the rice plants were recognized | 87.5% | Showed GoodReliability | Performance of this method was low compared with other expert systems |
| Toran Verma and Sipi Dubey [46] | Radial basis function network (RBFN) model | Sheath Blight, Panicle Blast, Brown spot, Leaf Blast. | 95.5% | Good recognition efficiency and generalization | some of the diseases were not identified accurately |
| Maohua Xiao *et al* [47] | PCA and NN | Rice Blast | 95.83% | Identify the disease quickly and efficiently | Limitations exist in the recognition of lesions with similar morphology and color |
| Shampa Sengupta, Asit K. Das[48] | PSO – centered incremental classifier | Rice blast, Sheath Rot, Leaf brown spot, BB | 84.02% | Reduces the computational time | The results are not checked for incremental data and also the system may demand a self-adapted parameter setting scheme. |
| Jianrong Huang *et al*[49] | Hyperspectral data | RLF damage in rice | 82% | More accurate than others because of reflectance | Applicable only to specific fields due to the variation of spectra say, stages of growing, species of crop etc. |

| | | | | | |
|---|---|---|---|---|---|
| WeiJuan Yang *et al*[50] | A visual method based on PdNPs-catalyzed TMB/H2O2 system | blast fungus, Magnaporth e grisea | 85% | Sensitive, and cost-effectual methodology for the fast screening and for early diagnosis of M. grisea in rice plant | Cannot find Other sorts of diseases in rice. |

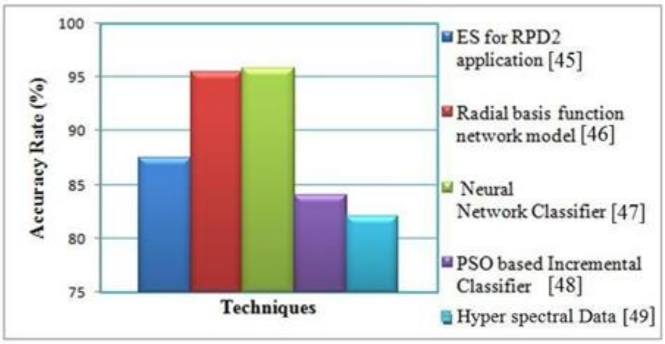
## IV. Discussion

Table 3 provides a summary of the various image processing and ML approaches utilized in the recognition of rice diseases. Different classifiers are used to identify various kinds of rice diseases like BB, rice blast, leaf brown spot, and sheath rot. Each method has its advantages. The accuracy of a number of different classification methods and image processing approaches used in various papers is compared and contrasted. Figure 2 provides a comprehensive explanation of the performance comparison graph presented in Table 3 for the various methods analyzed.




(a) Neuro-Fuzzy expert system, PCA-based SVM, Deep CNN, Faster R-CNN, and SVM:

The accuracy levels of these techniques were evaluated for the detection and classification of rice diseases.




(b) ES for RPD2, Radial basis function, NN classifier, PSO-based incremental classifier:

The accuracy levels of these techniques were also assessed for the detection and classification of rice diseases.

Figure 2: (b) Comparison of various techniques' accuracy levels (a) Neuro-Fuzzy expert system, PCA-based SVM, Deep CNN, Faster R-CNN, and SVM (b) ES for RPD2, Radial basis function, NN classifier, and PSO-based incremental classifier (c) ES for RPD2, Radial basis function, NN classifier, and PSO-based incremental classifier Several ML techniques were used to identify various rice diseases. When compared to other methods, the NN-based classifiers produced better results. For instance, the NN classifier used in [47] achieved the highest level of accuracy (95.8%), whereas the RBFN model used in [46] was able to detect diseases with an accuracy level of 95.5 percent. In addition, the accuracy rate of the SVM classifier used in [44] was the lowest of all the methods.

## VII. CONCLUSION

In conclusion, the rice plant disease recognition system's primary focus in crop disease management is rapid and precise disease prediction. Rice plant disease detection at an early stage enables paddy researchers and farmers to swiftly protect the plant. The survey and synopsis of the image processing and machine learning methods used to detect diseases in rice plants are the primary focuses of this work. Various segmentation methods were used to extract the diseased rice plant's leaf image. Researchers can use the strategies discussed in this paper to solve a variety of issues that directly or indirectly affect society. A method will be suggested for working on the current research problem and exploring ML and segmentation approaches, both of which have the potential to make disease recognition in plants easier, for future research. Future comparisons with traditional algorithms' performance and computational requirements may be possible.

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