

A Study on Rice Leaf Disease Using Deep Learning Techniques

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Abstract

Rice is the main source of food for many people around the globe. An automatic identification and classification of rice disease are very important in the domain of agriculture. The most common diseases seen in rice crops include bacterial blight, rice blast, brown spot, Tungro, sheath blight, and leaf smut. According to the World Bank, the predicted demand for rice is 57% or less by 2050. Therefore any damage of rice crops is unacceptable. Several diseases affect crop quality and growth. It can be difficult to diagnose a condition using traditional methods. A computerized system, on the other hand, is extremely useful in detecting disease at an early stage, allowing farmers to protect their crops from damage. This research evaluates the literature on several types of diseases in rice crops and makes comparisons based on accuracy, methodologies, and datasets utilizing Deep Learning and Image Processing Techniques.

Introduction

India's economy heavily depends on agriculture. Agriculture is the prime income source in various countries in the world. A large part of India depends on paddy cultivation. Most of the people in India like to eat rice as food. Worldwide, rice is a significant crop, and about half of the world's population depends on it. The scientific name of rice is *Oryza sativa*. India is the second largest rice producing country. It is the world's biggest rice exporter. Rice is the main part of Indian meals so a major portion of cultivation land is used for rice cultivation. Rice is one of the leading food crops in the world and the most consumed agricultural product with the highest market value. Out of the three major crops, wheat, rice, and maize, rice is far more for fulfilling more than 20% of daily caloric needs.

Nowadays the rice plants are facing many problems in the agricultural sector owing to disease which affects the quality and quantity of the crops. Lack of enough knowledge in fertilizer management, lack of awareness about rice leaf disease and pests are the reason for the lower production rate. Plants are affected by Bacterial and fungal disease. Farmers of developing countries use traditional method which requires more labour work and is more time consuming. It is also possible that manual detection or visible analysis cannot give fruitful results. Farmers face. One of the effective solution for farmers is processing the captured images of "seem to appear" infected leaves by an automated system. The automation system helps the farmers to be aware the disease instantly. Therefore, early disease detection is most important.

Several image processing Techniques and Deep learning algorithms are developed to identify the disease of the rice plant. Image processing techniques and Deep Learning algorithms are prove one of the accurate and economic practices for measuring the parameters related to various rice plant disease. Therefore, a rigorous survey comparative analysis of different image processing techniques have done in this paper, which are applicable for diagnosis of rice plant disease.

The images are captured from the Rice Plant Field. Those images are then pre-processed, and the infected parts of the leaves in the images are segmented. Then, from the segmented images, the features are extracted, and finally, deep learning techniques are used to perform the classification of the diseases. The success of such a system depends on how accurately it performs image processing and Deep Learning operations.

1.1 General Structure:

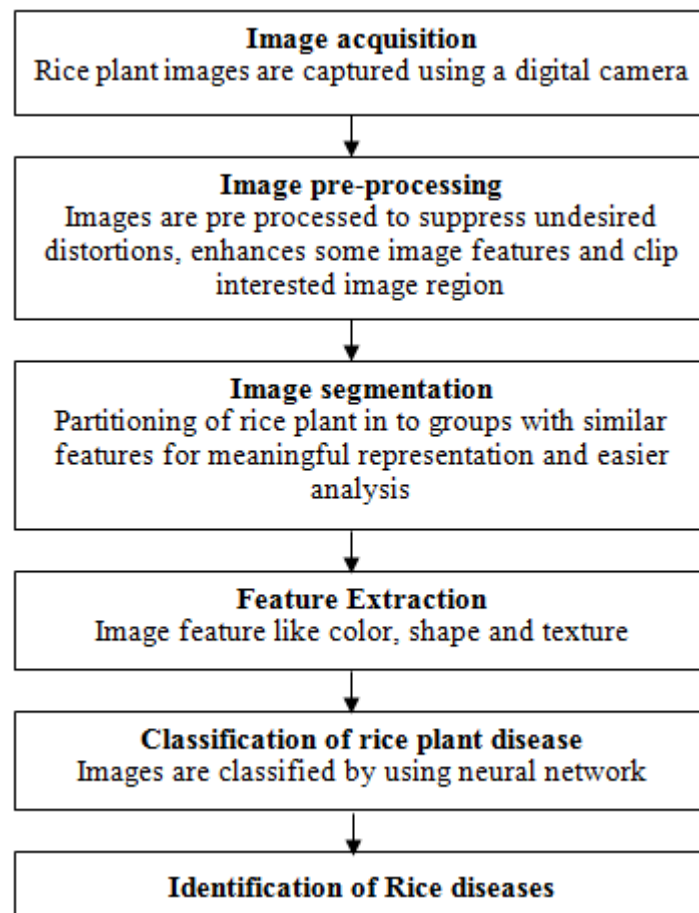


Figure:1 General structure for rice leaf diseases

The steps concerned in classification and detection of rice plant diseases are discussed as follows: 1) Image acquisition which captures the rice plant diseases utilizing a digital camera, 2) Pre-processing enhances the captured image features which improves the further processing data, 3) image segmentation divides the pre-processed images into groups with identical features for easier analysis, 4) feature extraction process extorts the features from the segmented based on shapes, colors, and textures and 5) classification process classifies several sorts of rice plant diseases. The processes embraced in identifying the rice disease are evinced in figure 1.

1.2 Rice Leaf Diseases and their Symptoms

There are different types of rice plant diseases. This division clarifies the dissimilar kind of infection that infested on rice plants.

The reason behind putting this section is that one can appreciate curved whatever kinds of pictures discussing processes would be wanted or what kind of structures want to be measured to articulate such viruses cognition structure, figure 2 shows images of six common diseases. We briefly define each disease.

1. **LeafBlast(LB):**The indication of the disease is black dots to oval dots, with reddish brown and gray or white points.
2. **Brown Spot (BS):** The disease infected on the leaves of rice. The indication of disease is round to oval, with dark brown lesions.
3. **SheathBlight(SB):** This infection suggests itself on both leaves and stems. The indication is oval, white or straw colour show in centre with reddish brown spots.
4. **Leaf scald (LS):** The symptoms are narrow reddish-brown wide bands. Sometimes the lesion is on the edge of the leaf, the border is yellow or gold.
5. **Bacterial Leaf Blight (BLB):** The indication have elongated lesions at the tip of the leaf, which are several centimetres long, and change from white to yellow due to the action of the bacterium.
6. **Rice Blast (RB):** It is because of the fungus *Magnaporthe Oryza*. The white to gray-green lesions or blemishes have a dark green border on the first time. The more obvious lesions on the leaves are oval or spindle-shaped, white to gray center, red to brown necrotic edge. Usually the spots are elongated and point at both end.
7. **Sheath Rot(SR):** It was created by two fungal species, *Sarocladium Oryza* and *sarocladium tensum*. Typical alcaseing root begins with the upper sheath of the spikelet. It looks like an oblong or asymmetrical stain with dark red, Brown edges, gray midpoint or brownish gray generally, more spots are experiential, these spots will expand, and rise can cover most of the leaf sheath. The panics remain in the cloa kormay appear partially.

Figure2: Different types of rice diseases



1.3 Different types of dataset For Rice leaf

In Deep Learning, Data is important for researchers, and image data plays a vital role. The process of constructing an appropriate dataset involves a large scale of image gathering to accurately represent the use case of the system. This, in turn, needs time and domain expertise to select relevant information and infrastructure to capture that data, which is transformed into a representation that the system can properly understand and learn. In this section, popular datasets mostly used for Rice leaf are described.

Kaggle dataset

Kaggle dataset contains 120 jpg images of disease infected rice leaves. The images are grouped into 3 classes based on the type of disease. There are 40 images in each class. Classes are Leaf Smut, Brown spot, bacterial leaf blight.

UCI Machine Learning Repository Dataset

UCI Machine Learning Repository Dataset: A dataset available in UCI Machine Learning Repository [5] contains a set of 120 images consisting of three types of diseases. These are, (a) Bacterial Leaf Blight, (b) Brown Spot and (c) Leaf Smut. Each class contains 40 images of disease-affected leaves. This dataset was made by manually splitting the affected leaves into different disease classes. The disease name of the sample image was confirmed by consulting with the agriculture experts. The images were captured with a white background in direct sunlight. Then it was reduced to the desired resolution for processing.

Git Hub dataset

This dataset [5] was created for an Image Recognition application. This dataset contains 278 images of three diseases, of which 96 are Bacterial Leaf Blight, 102 are Brown spot and 80 images are of Leaf Blast. All the disease-affected leaves that were captured as images in the datasets were of optimum age (3 to 4 weeks). Most of the images contain heterogeneous background.

Mendeley Dataset:

In this data-set[11], 39 different classes of plant leaf and background images are available. The data-set containing 61,486 images. It's used six different augmentation techniques for increasing the data-set size. The techniques are image flipping, Gamma correction, noise injection, PCA color augmentation, rotation, and Scaling.

PlantVillage

It has become the most commonly used dataset for training and developing deep learning-based plant disease identification and severity estimation models[17]. The Plant Village dataset consists of a total of 54,309 images. The images are divided across 38 different diseases affecting 14 crops. Most of the images were acquired under controlled lab conditions with uniform backgrounds. As images within the Plant Village dataset are not representative of real-field conditions, deep learning models trained to identify diseases using these images could not generalize with higher accuracy to images acquired under field conditions.

Rice Disease Dataset

A rice disease dataset consisting of 3355 images was also acquired [17]. A total of four disease classes are present, namely healthy, brown spot, hispa, and leaf blast. The dataset, however, consists of images acquired under controlled lab conditions with uniform white backgrounds. Therefore, such a dataset will make it difficult to train robust deep learning models capable of identifying rice diseases under field conditions.

2. Literature Review

This section describe with disparate research works on the diseases detection of rice. The core steps utilized in detecting the rice plant diseases are enumerated in table 1

Table 1: Basic image processing steps in the detection of rice plant diseases

Author name	Key technique	Diseases	Accuracy
Chen et al. Disease detection model for rice plant	DenseNet and Inception modules	“Rice stack burn, rice leaf scald, rice leaf smut, rice white tip, and rice bacterial leaf streak”	It achieves an accuracy of 94.07%
Wang et al. Identification method for rice plant disease	MobileNet	“Brown spot, Hispa, and rice leaf blast”	It achieves a test accuracy of 94.6 percent
Shivam et al. Rice leaf disease identification method	VGG-19, LeNet5, and MobileNet-V2	“Bacterial leaf, Brown spot, and Leaf smut”	Accuracies observed to be 77.09%, 76.63%, and 76.92%

These approaches take advantages of recognizing the rice diseases are explained below.

2.1 Methods to Diagnose the Rice Diseases

Md. Ashiqul Islam et al. [2021] proposed that if diseases can be detected at an early stage with great accuracy and in a short time, then the damages to the crops can be greatly reduced and the losses of the farmers can be prevented. This paper has worked on four types of diseases and one healthy leaf class of the paddy. The main goal of this paper is to provide the best results for paddy leaf disease detection through an automated detection approach with deep learning CNN models that can achieve the highest accuracy instead of the traditional lengthy manual disease detection process, where the accuracy is also greatly questionable. It has analysed four models, such as VGG-19, Inception-Resnet-V2, ResNet-101, and Xception, and achieved better accuracy from Inception-ResNet-V2 at 92.68% [11].

T P Senthilkumar and P Prabhusundhar (2022) proposed a new adaptive feature selection approach using a neural network. The dynamic dataset of rice leaf disease is used in this research article. The dataset is self-created. The accuracy of the proposed model is compared with the decision tree, CNN and SVM. The proposed model gave promising results for the classification of rice leaf diseases. The accuracy of the proposed model is 95.41% [13].

Mayuri Sharma et al. (2022) presented a comparative study of two classification models based on deep learning. In this work, two models are implemented, CNN with transfer learning and the ResNetV2 model. The authors considered three rice leaf diseases, rice blast, bacterial leaf blight, and brown spot, and develop a classification model for the comparison of accuracy. The work concluded that the model generated using transfer learning work with better accuracy [14].

AA J V Priyangka and I M S Kumara (2021) used VGG19, a CNN model used for the classification of rice leaf diseases. Seven rice diseases are considered in this work. The size of the dataset is 105 images from three different repositories. The overall accuracy achieved is 95.4%. The diseases studied are Bacterial Leaf Streak, Brown Spots, Narrow Brown Spots, Blast, Bacterial Leaf Streak, Fake Burns, and Healthy Rice Leaves. 15 images of each disease used. The data augmentation technique is used by authors for zoom range and sheer range [15].

2.2 Detection of Rice Plant Diseases Using Deep Learning Approaches

Rajesh Yakkundimath et al (2021) presented a comparison of two CNN models for the classification of three rice diseases. The models implemented are VGG16 and GoogleNet. The dataset consisting of 12000 images is used. 24 different symptoms are considered for the feature extraction. The accuracy achieved by VGG16 and GoogleNet is 92% and 91% respectively [18].

Santosh Kumar Upadhyay and Avadhesh Kumar (2021) used a deep learning algorithm for the classification of three rice diseases. The convolutional neural network is used by authors for the implementation of the classifier. The diseases taken into consideration are bacterial leaf blight, brown spots, and leaf smut. The dataset of 4000 images of three rice leaf diseases is taken from UCI, a standard online repository. The accuracy achieved by the model is 99.7% [20].

Mayuri Sharma et al. (2022) presented a comparative study of two classification models based on deep learning. In this work, two models are implemented, CNN with transfer learning and the ResNetV2 model. The authors considered three rice leaf diseases, rice blast, bacterial leaf blight, and brown spot, and develop a classification model for the comparison 27 of accuracy. The work concluded that the model generated using transfer learning work with better accuracy [21].

2.3 Segmentation method for detection of rice plant diseases

Table 2 enumerates the segmentation methodologies used in rice disease diagnosis

Table 2: Comparisons of various segmentation methods in recognition of rice diseases

Author name	Key technique	Description	Limitation
S. Ramesh , D. Vydeki[6]	Segmentation(K-Means Clustering)	To spot the infected leaf part of the rice plant.K –Means clustering method is applied to segment the normal portion and the diseased portion	Take more time spot the disease
MdErshadulHaque, Ashikur Rahman, IftekharJunaeid, SamiulUIHoque, Manoranjan Paul[9]	Segmentation (Yolov5)	Yolov5 Algorithm can quickly and effectively diagnose and classify lea0076es in big paddy fields, saving time and labor for the farmers.	Some of the rice leaf disease does not identified properly.
Sowmyalakshmi et al. (16)	Segmentation(CNNIROWELM-Convolutional Neural Network-based inception with ResNset v2 model and Optimal Weighted Extreme Learning Machine)	CNNIR-OWELM method involves a set of IoT devices which capture the images of rice plants and transmit it to cloud server via internet. The CNNIROWELM method uses histogram segmentation technique to determine the affected regions in rice plant image	The risk factors in the recognized diseases were not found

3.Methods used in detection of major diseases of rice:

SenthilKumar V et al. (2023) used DenseNet Bi-FAPN with YOLO v5 for the detection and classification of rice leaf diseases. Four bacterial diseases are chosen for classification. DenseNet-201 is used as the backbone network and depth-aware instance segmentation is used to segment the different regions of rice leaf. The proposed Bidirectional Feature Attention Pyramid Network (Bi-FAPN) is used for extracting the features from the segmented image and also enhances the detection of diseases with different scales. The Model achieved 92.45 accuracy in the classification of diseases [1].

Tiwari et al. (2021) a DL based methodology is proposed for the plant disease classification and identification from leaf images taken in different resolutions. The 6 crops in twenty-seven distinct classes are taken into account in the on-field condition and presented study. Images have many intra- and inter-class variances with challenging and complex situations that have been tackled in this DNN model. Five-fold testing and cross-validation on hidden data are performed for complete analysis of the trained models[14].

Trivedi et al. (2020) a CNN framework for plant disease identification with DL techniques were introduced. A CNN is trained by the 37 Plant Village Datasets consisting of 54,305 images including 38 distinct types of healthy and diseased leaves. The disease classification performance attained by the presented framework is up to 95.81% and different annotations have been made with distinct hyperparameters of the CNN framework[17].

Daniya&Vigneshwari (2021) presented a DL method for the spot diseases from rice crop image. Now, the RP images undergo pre-processing to eliminate artefacts and noise included in the image. Next, the segmentation is carried out using Segmentation Network (SegNet) for producing segments. Further, the segment is adopted to extract CNN, texture, and statistical features. Those features are used to plant disease recognition where the Deep RNN is used. The Deep RNN can be trained by the presented RideSpider Water Wave (RSW) method. Mahajan et al. (2020) presented a rice disease recognition method with different ML methods for recognition of rice diseases like LS, BLB, and BS. Past information is utilized for training the ML algorithms such as LR, DT, and KNN classifiers [26].

Sowmyalakshmi et al. (2021) introduced a new CNN-based inception using ResNset-v2 architecture and Optimum Weighted Extreme Learning Machine (CNNIR-OWELM)-based RPD classification and diagnosis method in smart farming environments. The presented model includes a group of IoT gadgets that captures the image of RP and send it to cloud server through internet. The CNNIROWELM model employs histogram segmentation method to define the diseased portions in plant images. Additionally, DL-based inception using ResNetv2 architecture is engaged for extracting the feature. As well, in OWELM, the WELM, enhanced by Flower Pollination Algorithm (FPA), is used for the purposes of classification[28].

Wang et al. (2021) proposed an attention-based depth wise separable neural network with Bayesian optimization (ADSNN-BO) to classify and detect rice diseases from leaf images. Rice disease often results in 20–40% crop productivity losses and is closely associated with the global economy. Fast disease detection is crucial for promptly planning treatment and reducing crop loss. Rice disease diagnoses are automatically executed. In order to attain AI enabled accurate and rapid disease diagnosis, we presented the ADSNN-BO method based augmented attention mechanism and MobileNet framework. Furthermore, Bayesian optimization algorithm is employed for tuning hyperparameters. Cross-validated classification experiment is performed on the basis of public rice disease data set with four classes altogether [19].

Debasish Kumar Mallick et al. (2020) used K-means clustering for the detection and classification of rice leaf diseases. Four fungal diseases are chosen for classification. The diseases included are leaf steak, tungro, leaf smut, and leaf blast. All diseases chosen are caused by fungus. The model achieved 80.6% accuracy in the classification of diseases [30].

4.Comparative Analysis

Several Deep Learning and image processing strategies utilized in the detection and classification of rice disease and contrasted and delineated in below table

Table 3:Comparisons of various approaches used in rice leaf disease diagnosis

Technique used	Disease identified	Dataset	Accuracy	Merits	Demerits
DenseNet-Bidirectional Feature Attention Pyramid Network (Bi-FAPN) with YOLOV5[1]	Bacterial Leaf Blight, Rice Blast, Brown Spot.	Kaggle Dataset 583 images	94.87%	Accurately and timely detect the disease	This methodology was not applicable for categorization of crop disease
Stacking-based integrated learning model with four convolutional neural networks (namely, an improved AlexNet, an improved GoogLeNet, ResNet50 and MobileNetV3) [2]	Aphelenchoidesbesseyi, bacterial leaf blight, red blight, leaf smut, rice sheath blight, bacterial leaf streaks, brown spots and rice blasts,	Canon EOS 6D MarkII digital camera 36 images Kaggle Dataset 1122	99.69%	Attained better segmentation accuracy Execution speed was augmented	Could not be applied in disparate field environments, indoor rice images, and disparate rice accession
Transfer learning approach on CNN models[3]	Bacterial Leaf Blight (BLB),Brown Spot,Hispa,LeaBlast,LeafScald,LeafStreak,Narrow Brown Spot,SheathBlight, Tungr	10880 images Kaggle dataset	99.64%	Improve the efficiency and accuracy of disease detection in rice plants. Identify diseases at an early stage.	The pigment of the plant was not properly extracted and types of diseases were not differentiated.
Multi-Scale Features Fusion Convolutional Neural Networks[4]	Rice leaf blast, helminthosporium leaf blight, and bacterial leaf blight,	1280 Kaggle dataset	93.71%	MSPCNN can provide the best identification accuracy and use the least amount of parameters and training time Achieve a better performance	Issues in tackling the noises and other lighting problems due to external forces
Three different CNN Models VGG16,ResNet50 and DenseNet121[5]	bacterial leaf blight, red blight, leaf smut, rice sheath blight	UCI Machine Learning Repository GitHub dataset	VGG16 80.59% ResNet50 23.63% DenseNet121 89.85%	DenseNet121- Attained Highest accuracy and Robustness	Performance of this method was low compared with other expert system ResNet50 has the lowest level of

					accuracy compared with others
Optimized Deep Neural Network with Jaya Optimization Algorithm (DNN_JOA).[6]	bacterial leaf blight, red blight, leaf smut, rice sheath blight	Directly captured from the farm field	97%	Accuracy level is high	Deep learning methodology contained several layers for classification. So it took more time to spot the diseases contrasted with others.
Attention Based Neural Network and Bayesian Optimization(ADS NN-BO) based on MobileNet and augmented attention mechanism[7]	Brown spot, hispa, and leaf blast.	2370 image	94.65%	Highest performance and make the procedure more effectively.	In this methodology does not separate the healthy leaves and Infected leaves.
Inception Resnet V2[10]	bacterial leaf blight, red blight, leaf smut, rice sheath blight	70000 images	97%	Farmers for detecting the diseases on plant in early stage so loss of yield can be reduced.	Computational Cost is High
Otsu's global thresholding technique[19]	Bacterial Leaf smut,Brown spot,Leaf smut	4000 images	99.7%	Reduce the time and enhancing the performance	Some of the rice leaf disease not identified Properly
SVM[21]	Rice Blast,Bacterial Leaf Blight,Sheath Blight,Healthy Leaves	619	91.37%	Detecting the Disease on plant in early stage.	Performance is very low
AlexNet	Healthy, Unhealthy	600	91.23%	Execution speed is high	Only Identified the Healthy and Unhealthy Leaf.

5. Discussion

Different methods to be developed in the recognition of rice disease, which uses image processing and Deep Learning approaches are summarized in Table 3. Different types of rice diseases like rice blast, Sheath blight, and bacterial blight are recognized. Different classification techniques and other image processing methods utilized in various papers and surveyed and their performance and accuracy. The performance comparisons of different method surveyed in this paper in detail using figure 3.

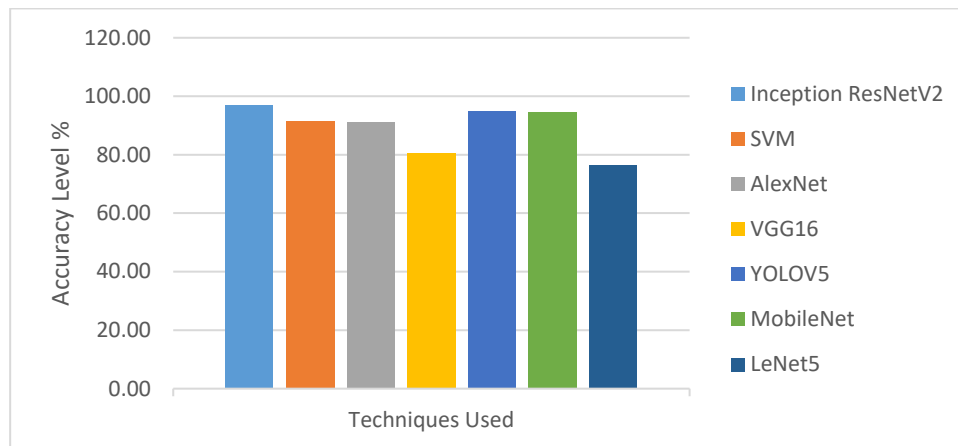


Figure 3 Accuracy level Comparisons of different techniques

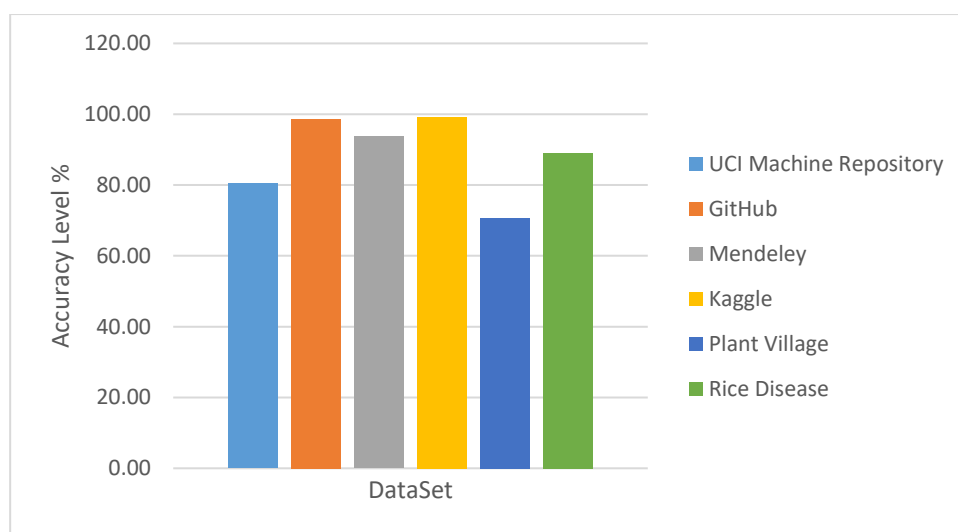


Figure 4 Accuracy level Comparisons of different Data set

Conclusion

Rice disease is the major issue encountered by most farmers; hence its early detection is very essential. In advanced Technology, identification of rice disease is very easier compared with manual Identification of rice disease.

This research paper focuses on Deep Learning techniques used for Rice leaf diseases. It analyses the result of most advanced as well as older models in deep learning methods. This paper is helpful for the researchers who are doing the research in the field of deep learning applied in the concept of rice leaf diseases.

Apart from the introduction about various network architecture information about various datasets that can be used for Rice Leaf disease are also discussed. Researchers can understand the information of various datasets and they can choose the appropriate ones for their research. The objectives and characteristics of the datasets are carefully stated. The disease affected leaf image of rice plant was extracted using various segmentation techniques. This paper help researcher in resolving a number of issues that either directly or indirectly influence society. For future work, a method will be suggested to work on the current research problem that was discussed above and also to explore Deep Learning and segmentation approaches that have the potential to make the disease recognition in plants easier. Future performance comparisons with traditional algorithms computational demands could be made.

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