

Classification and Functional Analysis of Major Plant Disease using Various Classifiers in Leaf Images



Kapilya Gangadharan, G. Rosilne Nesa Kumari, D. Dhanasekaran

Abstract: Plant disease interrupts the normal or Ordinary condition of a plant and it alters the essential functionality of a plant. Which intern impacts the productivity of the crop. Speedy observation, recognition and categorization of the plant pathogens will increase the crop yield more than 60% of the total productivity. Disease analysis is more evident on the leaves when compare to the other parts of the plants. Automated methods are most commonly available in different image processing techniques to detect the pathogen attack which can be made more efficient by combining multiple domain, that utilizes computer vision technologies. Most modern techniques or technologies are analyzed to identify the various disease on several crops or crop types. The paper summarizes about types of plants, types of plant diseases and the standard methodologies or technique that would help gaining knowledge about Computer Vision and its applications on plant disease identification and classification. Performance of the Classifiers are analyzed to recognize and classify the better method that typically works among different plant groups and different types of pathogen attack.

Keywords: Classification, Neural Network, Optimization, Accuracy, Efficient

I. INTRODUCTION

Agriculture or Crop Production depends on the quality and quantity of plant growth Worldwide. The pathogen detection on the effected plants or plant leaves engages different image processing techniques to alleviate the challenging task [1]. Multiple factors like Climatic condition, pest attack or diseases will cause the plant to have specific type of infection. Manual process of disease detection method is very long and tedious process, it is impossible for the farmers to identify the disease and factor of impact. So, it is highly recommended to adapt automatic disease analysis system Multiple techniques are applicable in identifying and classifying the effected portion of the plant [2,10]. Multi Crop, Multi disease are proposed in our System [3,22].

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Another method is proposed in [4] which is an automatic Citrus Canker detection from leaf images and proved that the accuracy is in the higher-level using Image Processing techniques when compared to that of Human experts on screen. The accuracy is calculated as 87.99% for Imaging Techniques. The Techniques detects the pathogens on the plants or plant leaves automatically at their early stage. In this study we analyzed both simple and complex pathogen attacks on the plant leaves using automatic systems in its primary stage which improves the amount and nature of yield generation and management.

From the analysis we observed that the disease detection under closed environment will face many difficulties due to unevenness of the circumstances, which is undergone by the agricultural field. There is a high necessity to adapt an automatic system or an algorithm to address the factor of change [5]. This paper has multiple methodologies to make the system more feasible, reliable and accurate which helps the research to move on a focused dimension [6]. Our work is structured or arranged as follows. Section 2 briefs about the various types of Crop on research for disease detection, Section 3 illustrates various types of diseases that effects plant leaves, Section 4 describes Architecture of leaves disease detection system using Image processing techniques, Section 5 presents the types of Classification methods on Multiple plant groups, Section 6 Consists of Performance Evaluation of Classifiers, section 7 has the conclusion and future work.

II. TYPES OF CROP ON RESEARCH

The major crops which is under research are broadly categorized into four major types based on the current state of research explored on the crops during last 10 years [6] which is mainly dependent on the usage. The four main categories of crops are 1. Food Grain Crops- 43%, 2. Cash Crops-10%, 3. Horticulture Crop-25% and Floriculture- 6%, 4. Others-16%. Fig [1] shows the research of Crops on the recent times. Which clearly shows that the research is mostly on the Food Grain Crop when compared to the other crops. Over all 43% of the total study is based on food crops [6]. The food Grain crop represented on research are Rice-14%, Wheat-6%, Legumes-14%, Corn- 7% and Clover leaves – 2%. Cash Crops are Cotton- 6% and Peanut 4%. Horticulture Crops are broadly classified into fruits-12% and vegetables- 13%, Fruits are Grape-10%, Orange- 1%, Lemon- 1% and

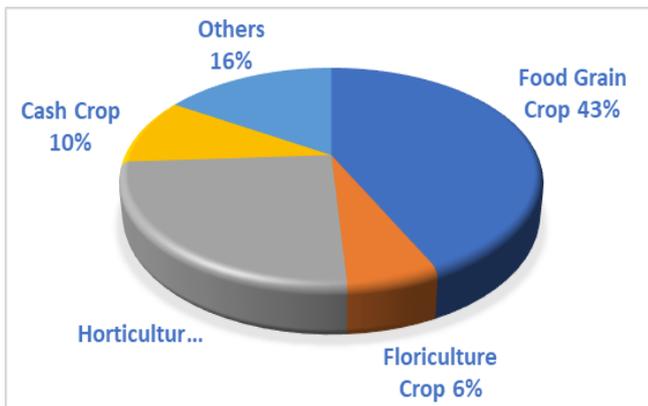


Fig 1 Percentage of Plant groups on research [6]

vegetables are Chili- 1%, Cucumber-6%, Tomato-6%. Floriculture Crops are Maple and Hydra-1%, Oil Palm Plant 4%, Phalaenopsis 1%.

III. TYPES OF PLANT DISEASES

Plant disease is broadly classified into two types, Biotic and Abiotic. Disease in the plants that is caused by any living organism is known as Biotic plant disease. Which can be further classified as Fungal disease, Bacterial disease, Viral

Disease and Insect Attack. When the disease that are formed due to the environmental change i.e., Non-living factors like weather, inadequate moisture, Chemical Substances, Freezing/Very hot temperature etc. Fig [2] and Fig [3] shows the types of plant diseases in different form.

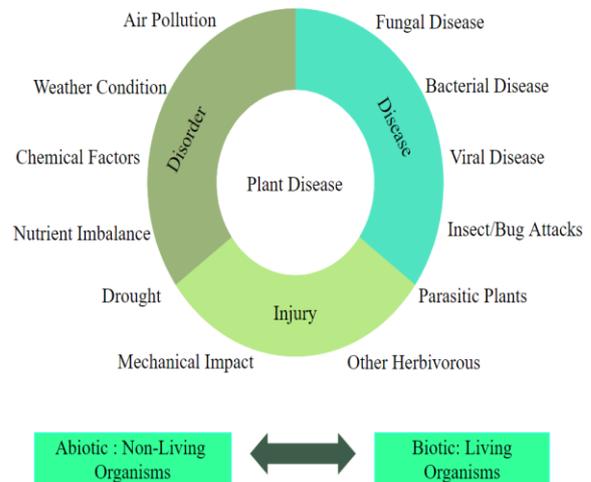


Fig 2: Classification of Plant Diseases

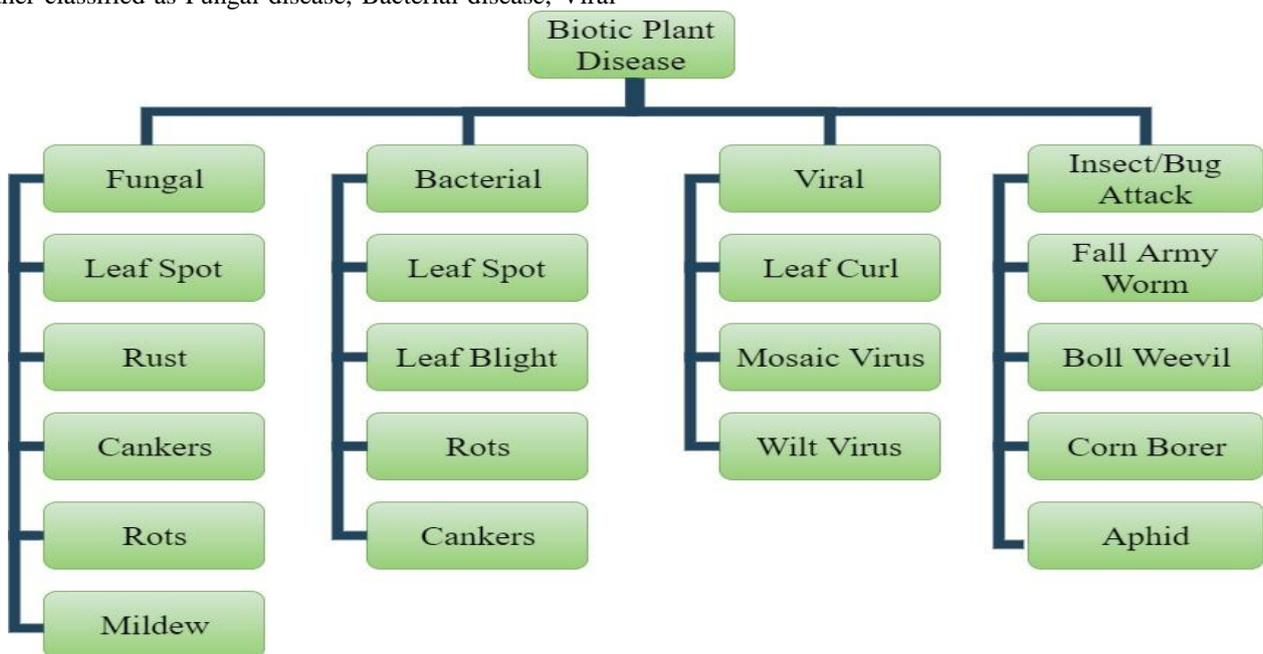


Fig 3: Biotic Plant Diseases

Biotic plant disease affect several species or culture of the same age. Abiotic diseases are non-infectious, not progressive and it will not spread from one host to other. We are focusing more on the Fungal, Bacterial disease in our paper which effects the food grain like Rice, Wheat, Soybean and Cash Crops like Cotton and Peanut.

Fungus is one of the main Biotic plant diseases, the pores created by fungus when it contacts with other plants or leaves it creates infection. It can be spread by means of wind, insects, water, direct contact etc. The other plant diseases like Virus, Bacteria are also vital. The diseases vary based on the plant group or types. The common categories of plant leaf diseases are as follows [7].

A. Leaf Spots

They are regular spots or blemishes which vary in its structure like shape, size and color. They are found in the multiple varieties of plant or leaves.



The spots may be generally black in color, when the spots grow together very closer to each other it forms blight or blotch. The leaf spots are caused by fungus or bacteria. It can also be called as frog eye leaf spot. It appears on all the varieties of plants.

B. Leaf Blight or Blotch

They are irregular in shape, size and color. They can be due to complete chlorosis, browning and death of leaf tissues. They are the advanced stage of spot disease. It can be caused by fungal attack. It includes corn leaf blight or early blight. It effects flowers, fruits and varieties of plants.



C. Rust

It is caused by fungus. The infection effects wheat, barley, rice etc., They look more or less similar to leaf spots with different color, shape and size. It can be bright amber, orange red, brownish red, black, grey or ash in color. It is very aggressive during winter.



D. Mildew

There are two types of Mildew they are powdery Mildew and Downy Mildew. Powdery Mildew is a fungal disease that effects wide variety of plants. Which would be powdery yellow substance on the leaves. Downy Mildew is also a fungal disease. It appears like a yellow or white patch on the surface of the leaves. It effects vegetables.



E. Leaf Cankers



It is caused by numerous species of fungus and bacteria. It is of various color, shape and size. The symptoms look like irregular sunken, uneven colored areas, cracked portion. It mainly targets woody species.

F. Leaf Rots

They are caused by fungus/ Bacteria effects cauliflower coconut plants, cotton etc., The leaves turn into yellow, reddish, brown or grey. Once it effects the leaves it will Wilt and die.



G. Leaf Curl



It is a most dangerous and destructive disease in tomatoes. It is caused by virus. It is a deformation and reciprocity of leaves. It also makes the leaves yellow or red. In peach it is caused by fungus.

H. Mosaic Virus

These are type of plant virus that will have sparkled appearance on the leaves. It is caused by several virus and spread by insects, fungus, nematodes, pollen etc.



I. European Corn borer

It is also known as European Corn Worm or European high-flyer. It forms a moth family. The insect infects grains like corn, rice wheat etc. It also includes grass moths. The infectious insect increases its production due to climate changes. It will damage the leaves by chewing tunnels on various parts of the leaves.



J. Boll Weevil

It is an insect that targets cotton plants. It destroys the cotton-based agriculture. It causes severe damage to the cotton production. It eats all the buds and lays egg in the plant.



K. Fall Army Worm

It refers to several species in the order of Lepidoptera. It is a pest that attacks large number of leaves, stems and other parts of plants. It damages peanut, corn, small grain crops etc.



L. Aphid



Russian wheat Aphid is one of the major insect pests. The affects the small grain family. It injects the toxin into the plant and damages the growth. It results in white Stripe all over the leaf.

IV. PLANT DISEASE ANALYSIS AND DETECTION THROUGH IMAGE PROCESSING TECHNIQUES

In our system we follow the normal Image processing techniques to analyze and detect the plant disease. The methodologies that we have adapted are as follows Image Acquisition, Preprocessing or Enhancement, Segmentation, Feature Extraction of the Image and Classification of diseases. Fig [4] is the flow of Basic Image Processing Methodologies in our system. The system also follows trained and tested Images for classification [6]. For training phase, the captured region of the image i.e., the leaf portion is taken and preprocessed by applying the required method like Image Smoothing/Noise reduction by applying the filter and it is corrected according to the requirement and segmentation method will be applied to it where spotting of the diseased region would be performed by separating the background with errored portion. Feature Vector mechanism will extract the region of interest and used for training the Classifier. In the testing phase, Image is passed through preprocessing, segmentation process and the feature extraction process, where the diseased area would be spotted and it would be identified through the trained classifiers. The Evaluation of the system is estimated through the accuracy of the output.

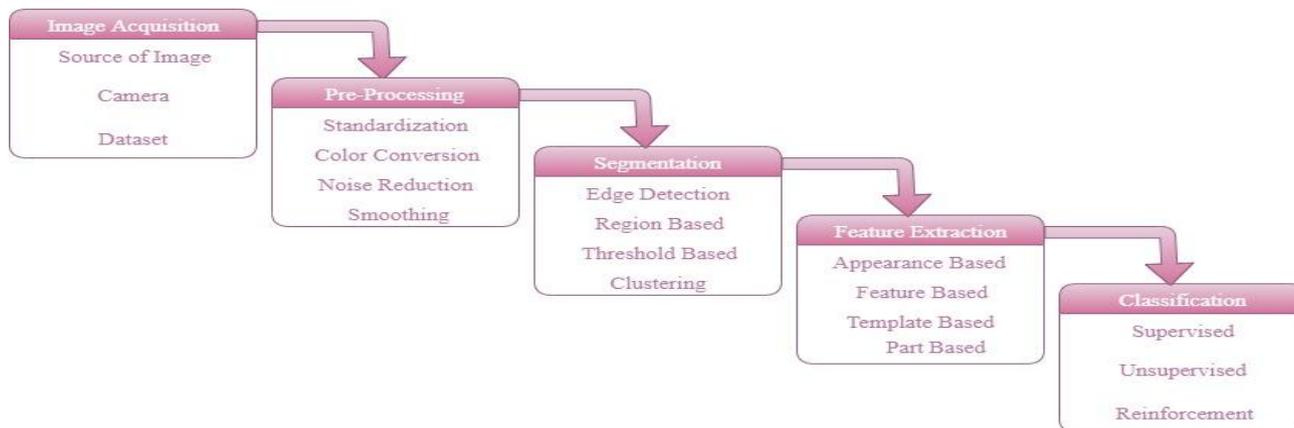


Fig 4: Basic Image Processing Methodologies

A. Image Acquisition

The algorithm/methodology is evaluated on the basis of input images used as the trained dataset. The Image quality is depending on the cameras used to capture the pictures. Most of the images were captured using Digital cameras, Multispectral cameras, Android mobile Cameras, iPhone Mobile cameras. Initial set of images were self-collected image captured using Drone. Few sets of Images were taken from a dataset which was available in the website [8]. Some images were scanned Images [9]. The accuracy of the output varies with the background of the input image and the capturing condition [2].

B. Image Pre-processing

Preprocessing techniques involve multiple methods like Color space conversion, Standardization, Smoothing, Noise filtering, Image Enhancement etc. It is a method to reduce the distortion/noise in the image, to enrich the sample or to wrench out any necessary information from the image. Image can be noised or distorted during the capture and transmission. HSI, HSV, YCbCr, CIE, RGB are the common color spaces available. Converting RGB to new Color space is more accurate [12]. Denoising an Image is very crucial factor in Imaging technique [11]. Filters like Mean, Median, Average or Sigma filters are applied to denoise the image. Contrast Limited Adaptive Histogram Equalization (CLAHE) method is used to adjust background of the image to produce better contract lighting condition [13].

C. Image Segmentation

It is an operation that divides the image into numerous segments or regions. Which is mostly used to identify the object or any feature that is present in the particular portion of the Image [48]. The border of the infected region could be identified using Edge detection method. Sobel, Prewitt, canny edge detection are popular methods [14]. K-means Clustering algorithm is the best when compared to Sobel algorithm, Prewitt algorithm and Canny methods [15,43]. K-means Algorithm could be combined with Watershed algorithm to Show accuracy. Determining appropriate Threshold value is very important in Segmentation process [16]. OTSU’s method are popular among the threshold-based segmentation methods [17]. OTSU’s method is used to derive the segmentation, Where the image is generated by the object and to differentiate it from the background, A gray value is introduced to the background and threshold is adopted to segment the image into two groups [18].

D. Feature Extraction

Feature indicated the characteristics of the image. It depends purely on the color of the image, texture or outline, shape of the image. Graphical representation of the image is plotted with the intensity of the color as histogram. Texture is used to identify the feature of the Image and the Shape is based on the template.

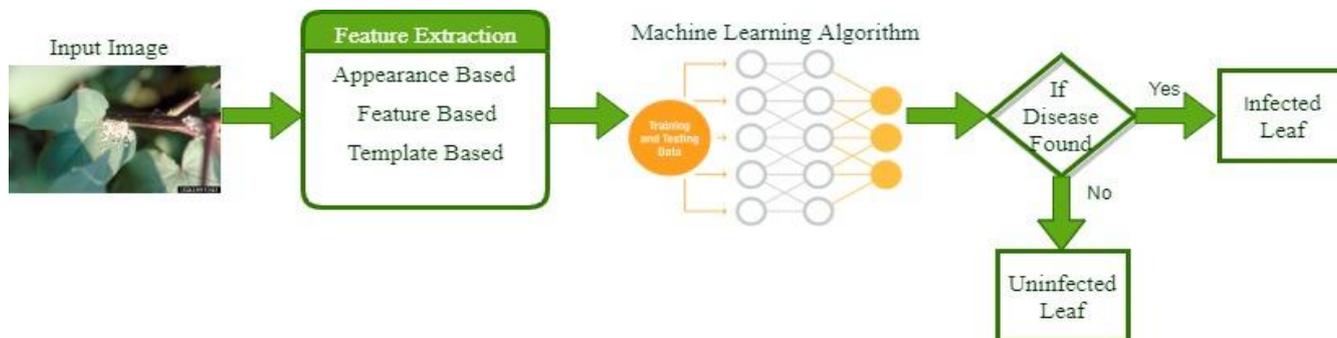


Fig 5: Flow of Classifier

Efficient disease detection methods adapt hybrid feature which combines Discrete Cosine Transform, Wavelet packet decomposition, Fourier transform and multiple different operators [19]. Color histograms and areas or other features are combined to detect the infected portion of the plant or leaf [20,21]. Average key points are obtained using (SIFT) Scale-Invariant feature Transform and SURF Speedup powerful feature method [23]. SIFT, Dense SIFT, Histogram of Oriented Gradient (HOG), SURF, Pyramidal Histograms of Visual words (PHOW) are compared to detect and classify the leaf disease [24]. Fungal disease can be detected in the early stage using Eigen Feature regularization and extraction techniques [25].

E. Image Classification

Image Classification is categorizing the image into number of predefined groups. Classification is a process that relay on the

characteristic of the Image dataset, Accuracy purely depends on the trained dataset. It is an Important process in the disease detection. The trained datasets are classified first and tested with the test set of Images. The main point in Classification is it should Identify healthy and unhealthy portion of the leaf Images. Classification of Image can be done using Machine learning methodologies. Fig [5] shows the

V. CLASSIFICATION METHODS ON MULTIPLE PLANT GROUPS

Fig [6] Shows the types of Machine Learning algorithms used as classification methods to identify the infection in the plant leaves. We are focusing on two types of Infection or disease they are Fungal and Bacterial diseases on Food grain crops and Cash Crops.

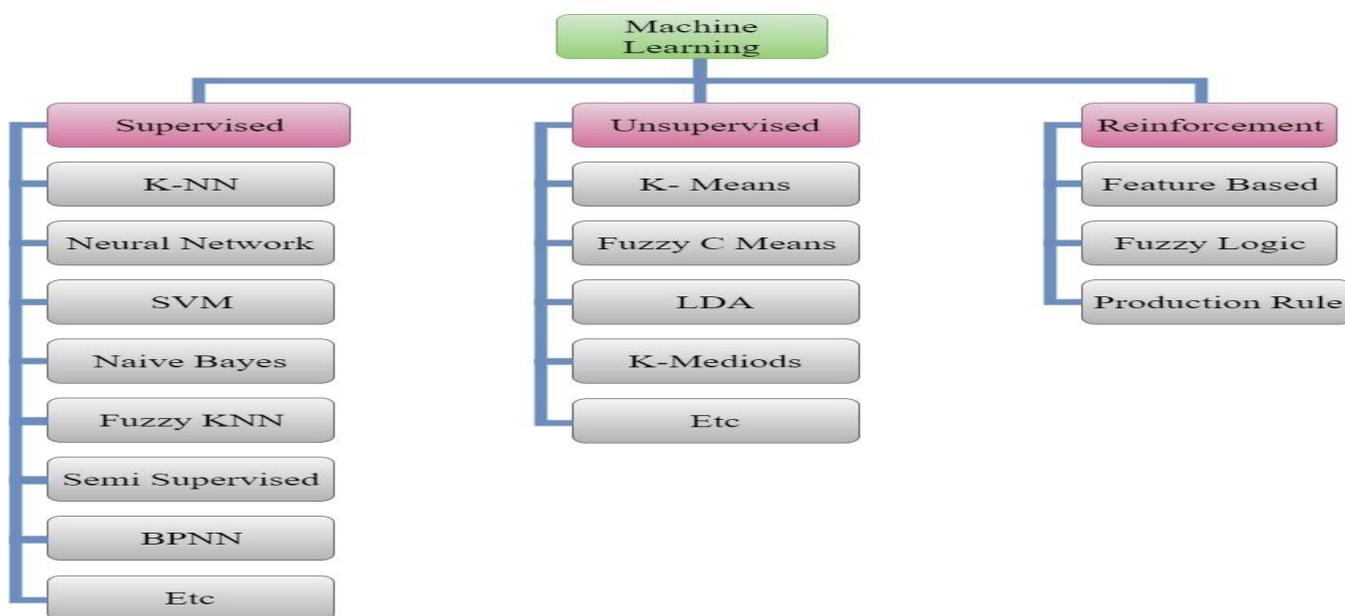


Fig 6: Types of Machine Learning Algorithms

A. Fungal Disease Classification

The Infections in the food grain crop are easily detected through Visualization. The visual aspect of these kind of infection is spots around the infected portion. From the analysis we found that most of the rice field is infected by Brown spot diseases. Research by Phadikar S, Sil -2008 [26] stated that the diseased images of paddy leaves are categorized using SOM-NN (Self Organizing Map Neural Network). In which samples are trained by discovering the characteristic of effected leaves. 4 different types of samples were used to train and 300 samples were tested. Accuracy range was between 70% to 90% with different cases. The research [27] has been carried out using Nearest Neighbor Classification to which recognizes the Sheath disease, Rice Blast diseases, Brown Spot and Bacterial-Bligh diseases. The average classification accuracy is more than 70% to recognize the infection and it utilized less than 2 seconds for computation. Phadikar S, Sil -2012 [28], proposed an

automatic system to detect two types of rice disease. Bayes classifier algorithm and SVM (Support Vector Machine) asserts the Brown Spot and Blast Diseases. Where they used 1000 number of samples as training and test images. The accuracy of 79.5% and 68.1 % has been achieved for Bayes' Classifier and SVM.

Another Method which is faster version of Neural Network called as PNN (Probabilistic Neural Network) is proposed by using Fractal Texture descriptor [38]. Over all accuracy of 91.80 % is achieved by the system. Where Brown Spot accuracy is 92.31%, Leaf Blast Accuracy is 83.0%. Phadikar S, Sil -2013 [29] designed rice disease identification system has been proposed with different Visual Properties. They have used Threshold based segmentation, to Calculate the threshold they have adapted Fermi energy method to extract regions.

Classification is derived using Rule Mining Technique. They have used Dataset of 14 test images and obtained Accuracy of 92.29%. Another work is proposed with SIFT to extract the characteristics from infected region of Paddy leaves. This work compares the performance of two methods, they are KNN (K- Nearest Neighbors) and SVM. It identifies Brown Spot, Leaf Blast fungal diseases in the Paddy leaves [30]. KNN – accuracy 93.33% performs well when compared to SVM – accuracy 91.10%.

Another system is designed which compares KNN, PCA and NN, Bayesian classifier to classify and recognize Brown spots on corn leaves. which resulted in 90% accuracy using KNN algorithm and 86.85% and 89.25% using PCA and Bayesian classifier [31]. Research by Srivastava S, Hooda DS (2014) [32] was on the crop Soybean, they have used image captured by Mobile phone and employed 50 testing samples of KNN classifier to detect and classify Brown Spots and Frog eye disease on the plant leaves. KNN classifier resulted in 70 % accuracy on Brown Spots and 80% accuracy on frog eye. Another research has been carried out in Soybean leaves to detect Brown Spot and Rust diseases using feature-based classifier [33]. The results are extracted using confusion Matrix. The accuracy for Brown Spot disease is 20% and Rust is 71% with the training dataset of 14 and 7 each.

The K-Means algorithm and NN is proposed to detect the Scorch disease in plants like peanut [34]. The algorithms developed proves that the efficiency of 94% has been achieved. The method has been tested using 32 Samples and the threshold is computed with the global thresholding method called OTSU’s method. A new method is formulated to identify 4 phases of Cercospora disease. BPNN (Back Propagation Neural Network) is proposed in the system [35]. The accuracy of the method was 97.41% with the training dataset of 360 images on Cercospora spots in the peanut plants. Geometric moment algorithm was introduced to detect the inadequacy in the peanut leaves to identify Mineral deficiencies [36]. The system generated 93% accuracy. Another method is proposed by using PCA/ KNN algorithm to analyze leaf spot disease in Cotton Leaves. 110 images where trained to classify the disease and achieved 95% accuracy [37].

B. Bacterial Disease Classification

A method called PNN (Probabilistic Neural Network) is proposed which uses Fractal Texture descriptor to identify the bacterial diseases in the paddy leaves. [38]. Over all accuracy of the system is 91.80 %. Where Bacterial leaf blight accuracy is 96.25%. Another work is proposed by [30] SIFT (Scale Invariant Feature Transform) to extract the features of Infected leaves. It identifies Bacterial Blight disease in the Paddy leaves. SVM predicts the result with accuracy of 91.10% and KNN with 93.33%. [33] Researchers have employed feature-based classifier to identify Bacterial Blast disease in Soybean leaves. They trained around 38 samples and tested around 18 samples and obtained the accuracy of 37.5%. [39]A system is developed that differentiates KNN, PCA and NN, Bayesian classifier which identifies Bacterial Blight on corn leaves. 90% accuracy is obtained using KNN algorithm and 86.85% and 89.25% using PCA and Bayesian classifier.

Decision Tree Classifier is employed to classify the health and diseases tomato leaves with bacterial leaf spots and Bacterial canker. 26 images where tested to obtain the accuracy of 69.2% and 84.6% of both the diseases. Phalaenopsis is a plant which is infected mostly by Bacterial soft rot and Bacterial brown spot [21], A method based on BPNN classifier is designed to identify the diseased leaves and they have BPNN classifier trained 144 datasets on color texture features which resulted in accuracy of 90.9% and 88.8%.

Bacterial blight on Cotton plant leaves has been identified and classified using Feed Forward BPNN Classifier. Which resulted in 85.52% of accuracy with the training set of 50 Images [40]. Another method is proposed to detect Bacterial Blight disease in Cotton leaves using ANN classifier [41] which provides around 85 to 91% of accuracy by training 120 good quality images. [37] proposed KNN algorithm to analyze leaf Blight disease in Cotton Leaves which proves 95% accuracy in classifying. 110 images where used to train and test the infection

VI. PERFORMANCE EVALUATION OF CLASSIFIERS

A. Fungal Disease

a. Brown Spot/Leaf Spot

We have taken two major types of Fungal diseases for observation Brown Spot / leaf Spot and Leaf blast fungal disease. Fig [7] denotes the graphical representation the

Table 1: Comparison of Fungal Diseases (Brown Spot and Leaf Blast) Detection and identification using Multiple Classifiers

Ref	Fungal Infection	Food Grain Crop			Cash Crop		Classification Methods	No of Sample Trained Images	% of Accuracy	
		Rice	Wheat	Corn	Soybean	Cotton				Peanut
[26]	Brown Spot	✓					SOM-NN	300	70 to 92	
[27]		✓					Nearest Neighbor	50	> 70	
[28]		✓					SVM	1000	68.1	
[28]		✓					Bayes	1000	79.5	
[38]		✓					PNN	40	92.31	
[29]		✓					Rule Mining Technique	14	92.29	
[32]						✓		K-NN	50	70
[33]						✓		Feature based	14	20
[31]				✓				K-NN	90	90
[31]				✓				PCA- and NN	90	86.95
[31]				✓				Bayesian	90	89.25
[35]							✓	BPNN	360	97.41
[30]		✓						K-NN	90	93.33
[30]		✓						SVM	90	91.1
[37]						✓		K-NN	110	94
[27]	Leaf Blast	✓	✓				Nearest Neighbor	50	> 70	
[38]		✓					PNN	40	83	
[29]		✓					Rule Mining Technique	14	92.29	
[30]		✓					K-NN	90	93.33	
[30]		✓					SVM	90	91.1	



performance evaluation of Brown Spot/Leaf Spot classification using different types of Classifiers that is applied in Multiple plant groups like Food grain crop and Cash Crops. From the analysis it is observed that Backpropagation Neural Network (BPNN) proves to be the best

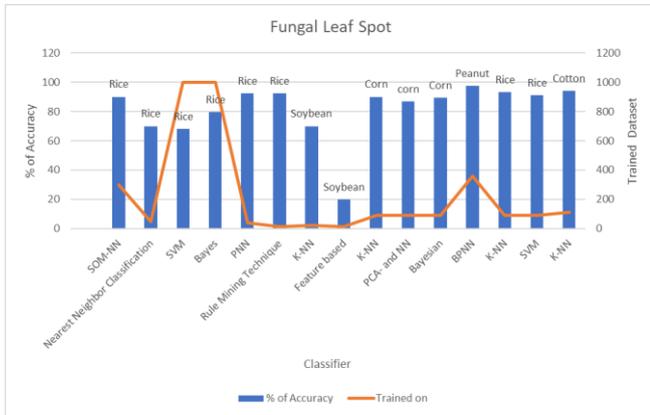


Fig 7: Performance Analysis of Multiple Classifiers in Identifying Fungal Leaf Spot disease

classifier which provides 97.41% accuracy which uses trained dataset of 360 images and tested on 40 Images.

b. Leaf Blast

Fig [8] represents the graphical representation of observed Fungal Leaf Blast disease on Paddy leaves. Where multiple classifiers are utilized to identify the blast infection on the leaves and its accuracy is calculated based on the of total number of training sets. From the analysis it is shown that KNN algorithm is more accurate than the other algorithms.

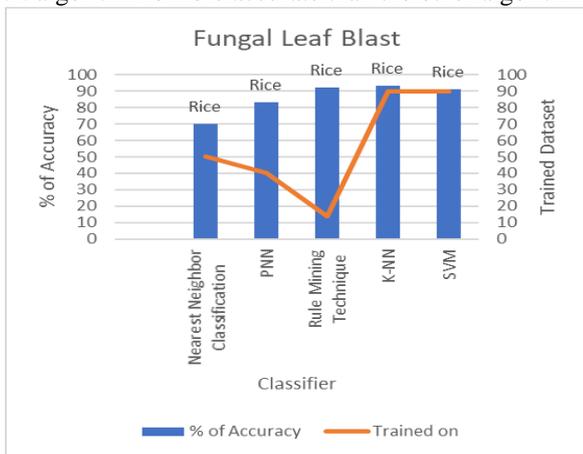


Fig 8: Performance Analysis of Multiple Classifiers in Identifying Fungal Leaf Blast disease

B. Bacterial Blight

The analysis has been made on plant varieties like Rice, Soybean, Corn and cotton. The infected leaves had been trained and tested for identifying the Bacterial blast disease. And it is observed that the KNN algorithm is better among the other classifier algorithms with the training dataset of 110 Images. Which is graphically represented in the Fig [9].

Table 2: Comparison of Bacterial Disease Detection Identification using Multiple Classifiers

Ref	Bacterial Infection	Food Grain Crop				Classifier	No of Sample Trained Images	% of Accuracy	
		Rice	Corn	Soybean	Cotton				
[30]	Bacterial Blight	✓				K-NN	90	93.33	
[19]				✓		LDA	57	75	
[33]				✓		Feature Based	38	37.5	
[31]			✓			K-NN	90	90	
[31]			✓			PCA- and NN	90	86.95	
[31]			✓			Bayesian	90	89.25	
[40]						✓	BPNN	50	85.52
[41]						✓	ANN	120	91
[37]						✓	K-NN	110	94

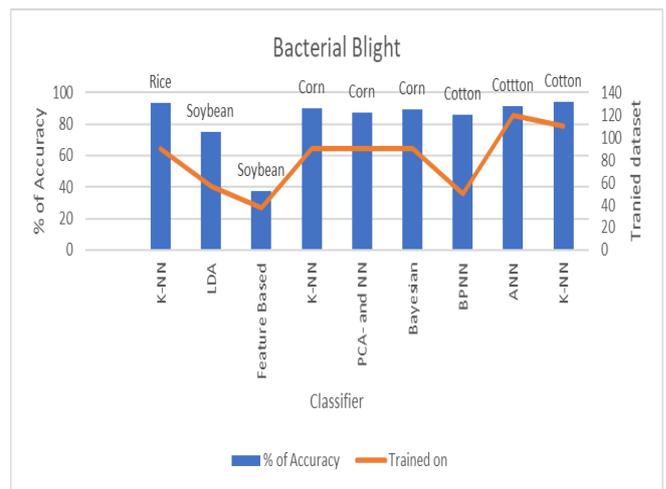


Fig 9: Performance Analysis of Multiple Classifiers in Identifying Bacterial Blight disease

VII. CONCLUSION AND FUTURE WORK

The paper compares various image processing methodologies like Image Acquisition, Preprocessing, Segmentation and Classification to analyze, detect and classify disease in the leaf image of multiple plants or culture. Where we mainly focused on the Classifiers to evaluate the performance. The performance of a system is purely based upon number of data-set used for training. It depends on the number of images used for training. From the analysis it is observed that well trained framework or system is profoundly effective. Over trained systems might produce inappropriate result. Proposing an inclusive method for each module and also comparing particular disease in a particular set of plant is very hard and difficult. Hence, we have compared different set of algorithms used to test different set of plants and diseases. From the analysis it is observed that using Back Propagation Neural Network Classifier performed better when compare to other algorithms like KNN, SVM, Bayesian, Feature based etc., But when the samples of multiple plant groups were tested using multiple Algorithms, KNN proved to be the best Algorithm. In the future to provide better performance we are focusing on developing a system which includes combination of best algorithms in both Image processing and Machine learning techniques.

As a future enhancement more training dataset can be included and tested using new Hybrid Algorithm to detect diseases which is combined with KNN and RBPNN classifier to produce a better result, reduced false positive results and to classify multiple diseases on variety of plant groups.

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