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Detection, Classification & Quantification of plant diseases using Digital Image Processing: A Survey

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Abstract

With natural calamities plant diseases also plays a major role in severe damage of agricultural product. As India is an Agricultural country, so this damage cracks the pillar of economy. So it is very much important to detect and prevent the crop from being affected by different diseases. This paper presents a survey on different types of Digital Image processing techniques to detect, classify & quantify plant diseases, in the visible spectrum. This paper is expected to be useful for researchers, working on Pathology on plants.

Keywords:

DiseaseDetection;
agriculture;
Pathogen;
DIP
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1. Introduction

Most of the Indian population contributes to the economy of the country through agriculture since they adopt farming and other related businesses as their way of living [4, 6]. Two main factors that affect our agriculture including irrigation, water stress, Fertilizers, pesticides and the quality of yield, where, mostly the crops or plantations are damaged either due to natural calamities like earthquake, floods, etc. or due to pathogens. Most of the time, it is found that the quality as well as the quantity of the agricultural products get reduced by the diseases affecting the plants and crops. In a developing country like India, the farmers in rural areas needs to be trained for properly detecting the diseases in crops so that the production can be increased.

However, for accurate detection of diseases occurring in plants as well as the type and quantity of pesticides that can be applied in cereal crops by measuring the extent to which the diseases cause potential harm to the crops, the techniques of image processing can be used in an efficient way. Hence, image processing can be better explained as a procedure to convert images in a digital way or either go for image enhancement or extraction of some useful information. In that sense, a form of digitally processed images, called digital image processing, makes efficient use of algorithms to process the image in a better way. Hence, image processing is that area of computer science which is used in various applications in agriculture starting from identification of diseases of fruits, leaves, stem, etc. of different plants, which can be viral, bacterial, or fungal in nature.

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Although much research has been carried out in the field of image processing for detecting plant diseases, still human error minimizes and reduces the time for obtaining a larger data set. In this field, Abdullah NE, Rahim AA, and Kamal MM (2007) has applied the technique of Principal Component Analysis (PCA) in a direct way to the RGB values of the pixels of a low resolution image of the leaves in order to discriminate a disease named "Corynespora" from other diseases that affect leaves of rubber trees. Here, the principal components are then fed to a Multilayer Perceptron (MLP) Neural Network with hidden layer. Here, image segmentation is not used.

Moreover, Sannakki SS and RajPurohit VS (2011) proposed a method for quantifying the disease on pomegranate leaves using fuzzy logic. Here, the algorithm converts the image to a^*b^* color space. The pixels are grouped into a number of clashes through K-means clustering. Here, the program calculates the percentage of infected leaf, but the accurate result could not be found out. In addition, Wang H., et.al.(2012) in their article, proposed a method to distinguish between pairs of diseases in Grapevines and Wheat. Here, image segmentation technique is used by K-means algorithm and features are extracted. Again, the authors used four kinds of neural networks like Multilayer Perceptron, Radial Basis functions, Generalized Regression, Probabilistic functions, etc. for classification of diseases. It gave god results.

Anand H.Kulkarni et.al. (2012) described how the captured image is filtered and segmented by using Gabor filter. Again the color and texture features are extracted and Artificial Neural Network is used for classification purpose. Here, the authors got the conclusion that the recognition rate can be up to 91%. So the result is encouraging.

Amar kumar Dey et.al. in their article, proposed a method "Otsu thresholding based on Image Processing algorithm for segmentation of leafrot diseases in betel vine leaf. Here the commonly used color models are RGB, HSV (Hue, Saturation, Value), and YCbCr (luminance and chrominance). But this paper represents that hue component of the HSV color model gives the clear perception of rotted leaf. It marks the background and rest of the leaf area. But, there is lack of separability near the edges of betel vine Leaf.

Monica Jhuria et.al. uses image processing for detection of disease and fruit grading in their paper. They have used artificial neural network for disease detection. They have created two separate databases – one for training of already stored disease images and other for the implementation of query images. Back propagation is used for the weight adjustment of training databases. The authors have considered three numbers of feature vectors i.e. color, texture and morphology. They have found that morphology gives better result than the other two.

Manisha Bhange.et.al. proposed a web based tool that helps farmers for identifying the fruit disease by uploading the image of pomegranate fruit to the system. The system contains already trained data set of images for the pomegranate fruit. The authors described that the input image is pre-processed and features are extracted based on the three parameters like color, morphology and CCV. K-means clustering technique is used for partitioning the training data set based on feature. SVM (Support Vector Machine) algorithm is used for training and classification. The authors conclude that when we deal with larger data set, K-means clustering algorithm gives greater efficiency. But, with the disadvantage that the system accuracy is only up to 82%.moreover, the dataset size should be improved in order to do more accurate disease detection.

Ehsan Kiani et.al. proposed an algorithm to distinguish between healthy and disease infected strawberry leaves, which doesn't require any neural network or time consuming training. In this paper, the authors describe two algorithms – Color Processing Detection Algorithm (CPDA) and Fuzzy Logic Classification Algorithm (FLCA). CPDA is used for detecting the healthy and disease infected area in plants and FLCA is used to find the type of disease on strawberry leaves which occurs due to iron deficiency or fungal infection. The proposed method doesn't use Neural Networks, required very minimal computation load which is favored by single chip processing machines. The overall accuracy rate is almost 97%.

The authors H.Ali et.al. proposed an algorithm called E color difference algorithm that is used for segmentation and further more, color histogram and textual features are used to classify diseases in citrus fruits. RGB and HSV are used for color histogram and LBP is used for textual descriptors. Again, KNN, Cubic SVM, Boosted tree and Bagged tree ensemble classification methods are used, where the author found out that the Bagged tree ensemble classifier performs better as compared to other features. With Bagged tree ensemble classifier, the classification results show 99% accuracy, 0.99% area under the curve and 99.7% sensitivity. The authors also have found that more training examples are required and till now, the proposed methodology is used only in citrus plants.

The authors M.Ray et.al. have reviewed several methods regarding the fungal diseases and fungal pathogens detection, with the help of biosensors. They have focused on the "gold standard tech" in fungal detection and have found the drawback that these methods require expensive equipments. Therefore, they have suggested some more modifications and improvements of biosensors in detecting the fungal disease.

K.P.Ferentinos have developed or used neural Network model for detecting plant diseases using the images of leafs of both healthy and diseased plants. The authors have proved that using Neural Network model, higher accuracy can be achieved. For training, the authors used an open database of 8788 images containing 25 different plants

3. Table:

Sl No.	Year	Paper Title	Authors	Proposed Work	Advantage	Disadvantage
1	2007	"Classification of Rubber Tree Leaf Diseases using Multilayer Perceptron Neural Network"	Noor Ezan Abdullah et.al.	Principal Component Analysis is applied directly to the RGB values of the pixels of low resolution images(15 * 15) – Classification is done by using ANN model. Principal Component applied to MLP Multilayer Neural Perceptron	Algorithm doesn't employ any kind of segmentation	accuracy can be improved
2	2011	"Leaf Disease Grading by Machine Vision and Fuzzy Logic"	Sanjeev S. Sannakki et.al.	Fuzzy logic is used to quantify the disease. The program calculates the % of infected leaf.	Reduces the production losses. Reduce time,complexity	Correct group identification is not possible.
3	2012	"Image Recognition of Plant Diseases Based on Backpropagation Networks"	Haiguang Wang et.al.	K Means algorithm is used for segmentation & 4 kinds of neural network used for classification.(multi-layer perception,probabilistic)	Good result for all kind of neural network	
4	2012	"Applying image processing technique to detect plant diseases"	Anand H. Kulkarni et.al.	Gabor Filter & ANN for feature extraction , disease detection, & classification	91% accuracy in classification	Morphology vector is not used
5	2013	"Image Processing for Smart Farming: Detection of Disease and Fruit Grading"	Monica Jhuria et.al.	Used Artificial Neural Network for detection of disease & color, texture morphology vectors are used for classification	Morphology gives 90% correct result	Color, texture does not give better result.
6	2015	"Smart Farming: Pomengranate Disease Detection using Image Processing"	Manisha Bhange et.al.	A Web based tool for detecting disease. SVM algorithm is used for training and classification	Accuracy level is 82%.	Detect disease only in Pomengranate. Data Set Size should be increased.
7	2016	"Image Processing Based Leaf Rot Disease, Detection of Betel Vine"	Amar Ku. Dey et.al.	Otsu thresholding is used for thresholding, RGB, HSI, YCbCr color models are used	Hue component of HSV gives clear perception.	Lack of separability near the edges of betel vine leaves.
8	2017	"Identification of plant disease infection using soft-computing: Application to modern botany	Ehsan Kiani et.al.	Studied two algo CPDA(color Processing detection algorithm) & FLCA(Fuzzy Logic classification algorithm) used for detection & classification of disease.	Does not require any neural network or any time consuming training. Occuracy level is 97%.	

9	2017	"Detection of plant leaf diseases using image segmentation and soft computing techniques"	Vijay Singh et.al.	Smoothing filter is used. Color occurance and SVM method is used for classification.	Early detection helps in controlling the disease.	Recogniti on rate can be improved .
10	2017	"Symptom based automated detection of citrus diseases using color histogram and textual descriptors"	H.Ali et.al.	ΔE color difference algorithm is used for segmentation. RGB and HSV are used for color histogram. KNN,Cubic SVM,Boosted tree and Bagged tree methods are used for classification.	99% accuracy in classification.	More training example are required. Proposed metod is used in citrus plant only.
11	2017	"Fungal disease detection in plants: Traditional assays, novel diagnostic techniques and biosensors"	M.Ray et.al.	Bio sensors are used for fungal pathogen detection and also focused on "Gold Standard" traditional technique.		Require expensive equipmen ts. More modificat ion and improve ment is needed for biosensor s.
12	2018	"Deep learning models for plant disease detection and diagnosis"	Shawen Zhang et.al.	Fusion of Super pixel clustering, K means clustering, Pyramid of Histograms of Orientation Gradients(PHOG) are used for segmentation and recognition.	Accuracy level is very high.	Images are collected by IOT. Proposed method is validated on two plant diseased leaf databases .
13	2018	"Plant diseased leaf segmentation and recognition by fusion of superpixel, K-means and PHOG"	K.P.Ferentino s et.al.	Used Neural network model for detection of plant disease	Success rate is 99.53%. Open database contains 87,848 images of 25 different plants.	

2. Research Method (12pt)

Basic steps for plant disease detection & classification

From the review of literature study, the basic steps for the plant disease detection and classification using image processing are

- Image acquisition
- Image preprocessing
- Image segmentation
- Feature Extraction from image
- Detection ,Classification & grading of disease

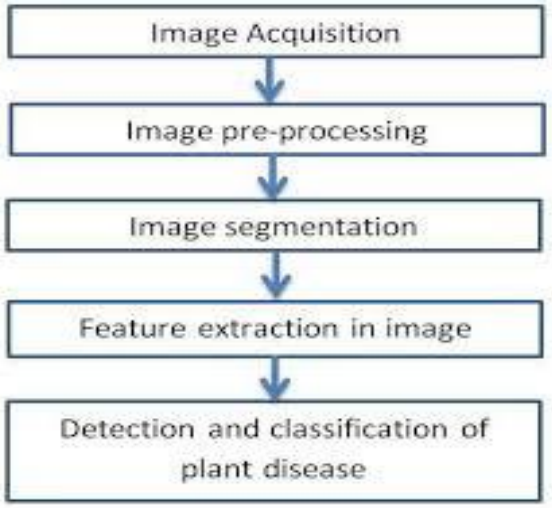

Fig.1. Basic steps for disease detection and classification

4.1. Image Acquisition

The images of plant leaf can be acquired using two ways. The first one is that the image can be captured by using digital camera and the second one is that the image can be collected from various resources like internet. After collecting the images are stored in image database for training and testing. The database itself is responsible for better efficiency and robustness of algorithm. The digitization and storage of an image is referred as the image acquisition [14].

4.2. Image Preprocessing

The main aim of image preprocessing is improvement of some image features which is important for further processing and analysis task by performing some techniques like image resizing(images are captured by digital camera, so image size is very large. Due to large size of image, it takes a lots of time for processing), Image clipping (cropping of leaf image to get the required dimensions of image region),image smoothing (done by using different smoothing filter),image enhancement(increase the grey level).

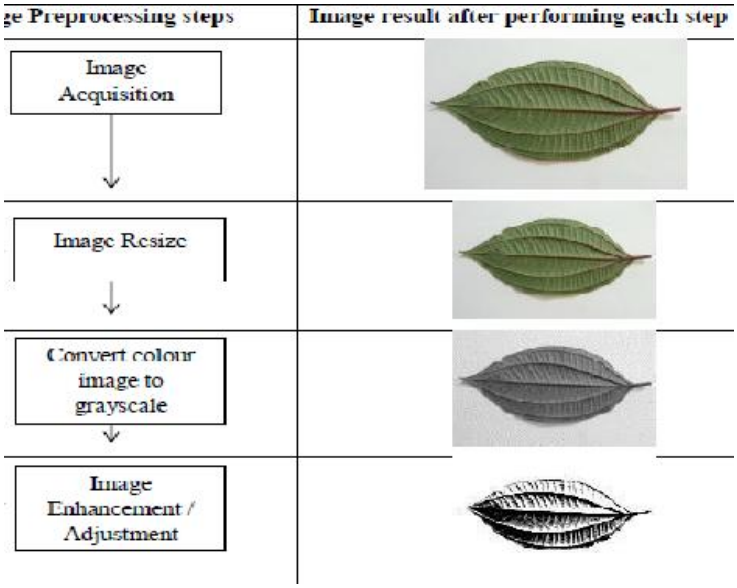

Fig 2. Result after performing each pre-processing step

But in the 1st step of of preprocessing images are resized to reduce the computational time as well as for utilize the storage capacity. There may be noise present in the image,which will affect the segmentation and also feature extraction. So in the 2nd step the noise must be removed by applying appropriate filtering operation before further analysis.

4.3. Image Segmentation

It is the process of partitioning a digital image into constituent regions [2][20].The result of image segmentation is a set of regions that collectively cover the entire image. In a single region all the pixels are similar with respect to color, texture, intensity. Adjacent regions are different from each other with respect to some feature [20]. Image segmentation changes the representation of image into something that is more meaningful and easier to analyze [4]. The segmentation can be done by using various technique like Otsu's method, k means clustering, converting RGB to HIS model, genetic algorithm etc

i) K-means Clustering

K-means clustering is used for classification of object, based on cretin features, into k number of classes or we can say it can be used for segmenting the image according to their features. One important advantage of K-means clustering is that, with larger data set ,it gives better efficiency[2,6,14,17].The k-means clustering algorithm is defined by Manisha Bhang et.al. is as follows

Input: Dataset, K number of desired clusters.

Output: K set of clusters.

1. Initialize the number of cluster k, and also pick initial centroid randomly.
2. The squared Euclidean distance will be calculated from each image to each cluster is computed, and each object is assigned to the closest cluster.
3. For each cluster, the new centroid is computed and each seed value is now replaced by the respective cluster centroid .
4. Euclidean distance from an object to each cluster is calculated, and the image is allotted to the cluster with the smallest Euclidean distance.

   This process will be continuing until image is in same cluster at every iteration.

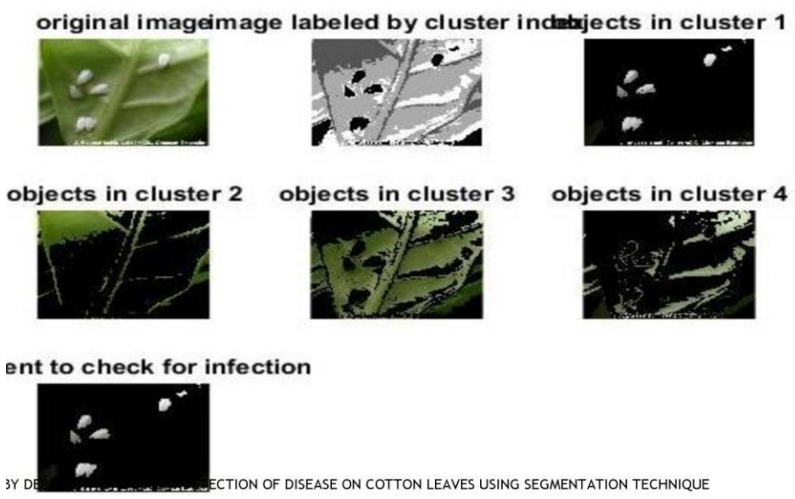

Fig-3. cluster generated by K-means clustering algorithm

ii) Otsu's Threshold Algorithm

Thresholding creates binary images from grey-level images. Here the RGB components are extracted from the image & threshold is calculated using Otsu's method. The Otsu's algorithm is defined in [14] by Sachin D. Khirade is as follows.

1. According to the threshold, separate into two clusters.
2. Then find the mean of each cluster.
3. Square the difference between the means.
4. Multiply the number of pixels in one cluster times the number in the other

iii) Segmentation using Boundary and Spot detection algorithm

This technique is implemented by Amar Ku Dey [7] in his paper. According to [7] the RGB model is converted into HIS model for segmentation. The boundary detection and spot detection is very useful for finding the infected part of the leaf.

4.4. Feature Extraction

Some features which can be used in plant disease detection are color, texture, morphology, edges etc. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image called edge[20].Again how the color is distributed in the image , the roughness, the hardness of the image is known as the texture of the image.
Monica Jhuria et.al in paper [3] used the color, morphology & texture for feature extraction. But she has got better results for color and morphology as compared to texture [3].
But Manisha Bhange et.al. in their paper [6] extracted features on three parameters namely- color, morphology & CCV of pomegranate leaves. Monica Jhuria Describes how by using color co-ocurance method RGB image is converted to HSI translation [5].

$$H = \{theta \quad if\ B < G \text{……..(1)}$$
$$\{360 - theta, if\ B > G$$
$$S=1-3/(R+G+B)\text{……..} \quad (2)$$
$$I=1/3(R+G+B)\text{…….} \quad .(3)$$

In paper [15] Pallavi converted the image to grey-scale by using the following equation.

$$f(x) = 0.2989 * R + 0.5876 * G + 0.114 * B \text{……(4)}$$

4.5. Detection, Classification & Grading

Classification & Detection

For classification and detection, the following methods are used by the authors in their paper:

i) Support Vector Machines

Support Vector Machine (SVM) is a learning model associated with a learning algorithm to analyze the data for classification[6,15]. SVM constructs hyper plane or set of hyper-planes which maximizes the margin and can be used for classification. Hyper plane achieved a good separation that has the largest distance to the nearest training data point of any class, known as *functional margin.*

SVM uses nonlinear data into higher dimensions. Dimension boundary separate tuples from one class to another. Training time of SVM is slow but they are highly accurate [6].

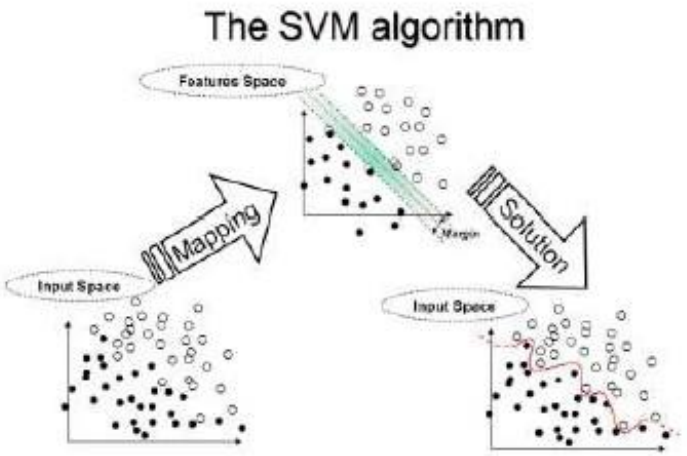

Fig-4. Support Vector Machine

Again the success of classification is measured by the following equation which is used in paper by Vijay Singh et.al.[9]

$$Gain(\%) = \frac{(number\ of\ correct\ classification)}{(Total\ no.of\ tes\ timages)} * 100$$

ii) Back Propagation

BPNN algorithm is used in a recurrent network. Once trained, the neural network weights are fixed and can be used to compute output values for new query images which are not present in the learning database.

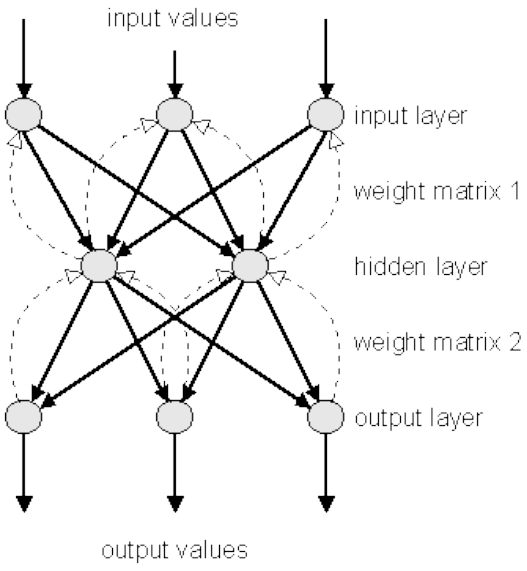

Fig 5. Back propagation network

iii) Artificial Neural Network

Artificial Neural Network (ANN) is highly inspired by the information processing system of biological nervous system. It is composed of large number of highly interconnected processing elements called neurons [4]. Here, the feature vectors are considered as neurons in an Artificial Neural Network (ANN) [5].
The function of the weighted sum of the inputs is the output of the Neurons.

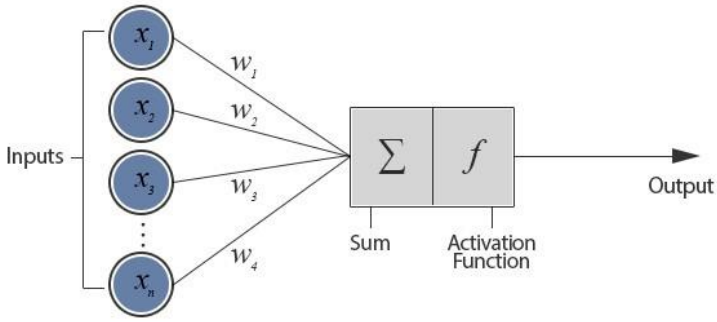

Fig 6. Artificial Neural Network

So, the entire neural network is the computation of output of all the neurons.
Grading

SS Sannaki et.al. beautifully describe how fuzzy logic can be used for disease grading or quantification. Fuzzy logic was first introduced by Lotfi Zadeh in 1965[2]. According to the author the Percent-Infection (PI) is calculated by applying the following formula.

$PI = \left(\frac{A_D}{A_T}\right) * 100$

Where, PI= Percent –Infection
A_T= Total leaf area
A_D= Total Diseased area

The total leaf area of binary image is the total number of 'on' pixels in the image. Again the output image is containing disease spots , used to calculate total diseased area A_D.

5. Conclusion

For the successful cultivation, accurate disease detection, classification & quantification is very important. This survey paper tired to represent a comprehensive study which might be the starting point for those, who are conducting research on this subject
Scope of doing future work:

1) Database used for training purposes can be extended to reach at more accuracy.
2) Work can be extended to cover more diseases.
3) There is also a scope of development of Hybrid algorithms (combination of genetic algorithm and neural algorithm) in order to increase the recognition rate in classification process.

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