Plant Disease Detection Techniques: A Review

Gurleen Kaur Sandhu
Student
Department of Computer Science and Engineering
Punjabi University, Patiala
gurleensandhu08@gmail.com

Dr. Rajbir Kaur
Assistant Professor
Department of Electronics & Communication Engineering
Punjabi University, Patiala
rajbir277@yahoo.co.in

***Abstract*-Plant diseases cause major losses in terms of production, economy, quality and quantity of agricultural products. Since, 70% of Indian economy is dependent on agricultural yield, there is a need to control the loss incurred by plant diseases. The plants need to be monitored from a very initial stage of their life-cycle to avoid such diseases. The traditional method being followed for this supervision is naked eye observation which is more time-consuming, expensive and a lot of expertise is required. So, in order to speed up this process there is a need to automate the disease detection system. The disease detection system needs to be developed using image processing techniques. Many researchers have developed systems based on various techniques of image processing. This paper reviews the potential of the methods of plant leaves disease detection system that facilitates the advancement in agriculture. It includes various phases such as the image acquisition, image segmentation, feature extraction and classification.**

Keywords- Plant disease detection, image processing, image acquisition, segmentation, feature extraction, classification.

I. Introduction

Agriculture is an important source in the economic development of India. About 70% of Indian economy relies on agriculture. Hence, damage to the crops would lead to huge loss in productivity and would ultimately affect the economy. Leaves being the most sensitive part of plants show disease symptoms at the earliest [1]. The crops need to be monitored against diseases from the very first stage of their life-cycle to the time they are ready to be harvested. Initially, the method used to monitor the plants from diseases was the traditional naked eye observation that is a time-consuming technique which requires experts to manually monitor the crop fields [2]. In the recent years, a number of techniques have been applied to develop automatic and semi-automatic plant disease detection systems. These systems have so far resulted to be fast, inexpensive and more accurate than the traditional method of manual observation by farmers [3]. Thus, this invokes researchers to deploy more intelligent technological systems for plant disease detection which do not require human intervention.

The objective of this paper is to review various techniques of plant disease detection and discuss in terms of various parameters. The paper is organized into the following sections. First section gives a brief introduction to the importance of plant disease detection. Second section discusses the existing work carried out recently in this area and also reviews the techniques used. Section three includes basic methodology followed for developing disease detection system. Lastly, fourth section concludes this paper along with future directions.

II. Literature Review

D.A. Bashish, et.al (2010) opted for k-means segmentation for partitioning the leaf image into four clusters using the squared Euclidean distances. The method applied for feature extraction is Color Co-occurrence method for both color and texture features [4]. Finally, classification is completed using neural network detection algorithm based on Back Propagation methodology. The overall system disease detection and classification accuracy was found to be around 93%.

M.Bhange et.al (2015) A web based tool has been developed to identify fruit diseases by uploading fruit image to the system [5]. Features extraction has been done using parameters such as color, morphology ans CCV (color coherence vector). Clustering has been done using the k-means algorithm. SVM is used for classification as infected or non-infected. This work achieved an accuracy of 82% to identify pomegranate disease.

J.D. Pujari et.al (2015) has taken a number of crop types namely, fruit crops, vegetable crops, cereal crops and commercial crops to detect fungal diseases on plant leaves. Different methods have been adopted for each type of crop [6].

- For fruit crops, k-means clustering is the segmentation method used, texture features have been focused on and classified using ANN and nearest neighbor algorithms achieving an overall average accuracy of 90.723%.
- For vegetable crops, chan-vase method used for segmentation, local binary patterns for texture feature extraction and SVM and k-nearest neighbor algorithm for

classification achieving an overall average accuracy of 87.825%.

- The commercial crops have been segmented using grab-cut algorithm. Wavelet based feature extraction has been adopted using Mahalnobis distance and PNN as classifiers with an overall average accuracy of 84.825%.
- The cereal crops have been segmented using k-means clustering and canny edge detector. Color, shape, texture, color texture and random transform features have been extracted. SVM and nearest neighbor classifiers used getting an overall average accuracy of 83.72%.

V. Singh et.al (2016) has worked on automating the detection and classification of plant diseases by implementing genetic algorithm as the image segmentation technique. A small number of images have been used for the training and test sets for four plants leaves namely, banana, beans, lemon and rose. Color co-occurrence method has been used for feature extraction considering both color and texture features. The Minimum Distance Criterion using k-mean clustering and the SVM classifier have been used to classify the diseases showing an accuracy of 86.54% and 95.71% respectively [7]. Combining the Minimum Distance Criterion classifier with the genetic algorithm increases the accuracy to 93.63%.

E.Kiani et.al(2017) has made an attempt to identify disease infected leaves at strawberry field under outdoor conditions using a fuzzy decision maker. An overall accuracy of detection and segmentation of plant diseases reached 97% and processing time was 1.2 seconds for detection of the diseases [8].

H. Ali et.al (2017) Their work aims to apply ΔE color difference algorithm to separate the disease affected area and uses color histogram and textural features to classify diseases achieving an overall accuracy of 99.9% [9]. A variety of classifiers have been used such as fine KNN, Cubic SVM, Boosted tree and Bagged tree classifiers. The bagged tree classifier out-performs the other classifiers achieving 99.5%, 100%, 100% accuracy on RGB, HSV and LBP features respectively. Fine KNN, cubic SVM and Boosted tree classifiers performed well achieving 88.9%, 90.1% and 50.90% accuracy respectively.

G. Saradhambal, et.al (2018) proposed an approach to produce a system for automatic plant disease detection. Research was carried out to predict the infected area of the leaves by applying k-means clustering algorithm and the Otsu's classifier. Both the shape and texture features were extracted in the proposed work. The shape oriented features that were extracted in this work included area, color axis length, eccentricity, solidity and perimeter, whereas the texture oriented features were contrast, correlation, energy, homogeneity and mean [10]. And lastly, classification in this research was done using a neural network based classifier.

TABLE 1: TABLE OF COMPARISON

Authors	Year	Description	Outcomes
D.A. Bashish, et.al	2010	The author has used k-means clustering to partition leaf image into four clusters assuming that atleast one of the clusters shall have diseased pixels.For feature extraction, a CCM method was developed through the use of Spatial Gray-level Dependence Matrices (SGDM). This method gives us the textural oriented features. Classification was done based on neural network using feed forward back propagation algorithm (BPNN).	The overall system disease detection and classification accuracy was found to be around 93%. Whereas, the best overall average accuracy of 99.66% was achieved using HS color features in BPNN. The following texture oriented features were found, angular moment, mean intensity level, variance, correlation, product moment, contrast and entropy.
M.Bhange et.al	2015	The k-means clustering gives greater efficiency when applied on large datasets hence it was used for segmentation in this paper. The color histogram of two images has been compared using sum of squared distances. Morphology is useful for boundary extraction or the shape vector. CCV is used for comparing images having spatial information. In this work, SVM is used for classification.	Using SVM, the authors were able to achieve 82% overall system accuracy. The training time of Support vector machine is slow but they are highly accurate. As a result, three feature vectors were obtained i.e., one for color histogram, morphology and CCV each.

V. Singh et.al	2016	For performing clustering, the search capability of genetic algorithm has been used, to separate unlabeled points of N-dimension into K clusters. In CCM methodology, both texture and color of an image have been considered. The minimum distance criterion was used in two methods i.e. one with k-means clustering and the other with Genetic algorithm.	Texture features included Local homogeneity, contrast, cluster shade, energy and cluster prominence which are computed for the H image. The minimum distance criterion with k-mean clustering gave an accuracy of 86.54% and with SVM the accuracy was 95.71%. Using Genetic Algorithm along with the minimum distance criterion increased the accuracy to 93.63%.
E.Kiani et.al	2017	The algorithm has five inputs and two outputs. Two of the inputs refer to the iron deficiency and the remaining refers to fungal infection. The outputs refer to the two diseases if the leaf is diseased.	The authors of this work were able to achieve an overall system accuracy of 96% using the proposed algorithm.
H. Ali et.al	2017	The delta E color difference based algorithm calculates the distance between two colors. LBP (local binary patterns), RGB histogram and HSV histogram features are used for feature extraction.	In RGB histogram, we get the rotation invariance. In HSV histogram as feature, we get the illumination invariance caused due to different lightning conditions.
G. Saradhambal, et.al	2018	The Otsu's algorithm assumes image to contain two classes of pixels i.e. it forms bi-modal histogram with the foreground and background pixels. For feature extraction, shape and texture oriented features were used.	The shape oriented features used werearea, color axis length, eccentricity, solidity and perimeter whereas, contrast, correlation, energy, homogeneity and mean were the texture oriented features.

Plant Disease Detection Process

The process of plant disease detection system basically involves four phases as shown in Fig.1. The first phase involves acquisition of images either through digital camera and mobile phone or from web. The second phase segments the image into various numbers of clusters for which different techniques can be applied. Next phase contains feature extraction methods and the last phase is about the classification of diseases.

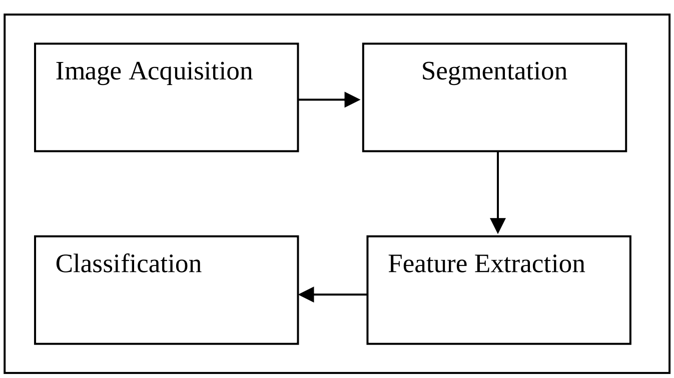

Fig. 1. Phases of plant disease detection system

Image Acquisition

In this phase, images of plant leaves are gathered using digital media like camera, mobile phones etc. with desired resolution and size. The images can also be taken from web. The formation of database of images is completely dependent on the application system developer. The image database is responsible for better efficiency of the classifier in the last phase of the detection system [11].

Image Segmentation

This phase aims at simplifying the representation of an image such that it becomes more meaningful and easier to analyze [12]. As the premise of feature extraction, this phase is also the fundamental approach of image processing. There are various methods using which images can be segmented such as k-means clustering, Otsu's algorithm and thresholding etc. The k-means clustering classifies objects or pixels based on a set of features into K number of classes. The classification is done by minimizing the sum of squares of distances between the objects and their corresponding clusters [13].

Feature Extraction

After segmentation, the outcome so far achieved is the area of interest. Hence, in this step the features from this area of interest need to be extracted. These features are needed to determine the meaning of a sample image. Features can be based on color, shape, and texture [14]. Recently, most of the researchers are intending to use texture features for detection of plant diseases. There are various methods of feature extraction that can be employed for developing the system such as gray-level co-occurrence matrix (GLCM), color co-occurrence method, spatial grey-level dependence matrix, and histogram based feature extraction. The GLCM method is a statistical method for texture classification.

Classification

The classification phase implies to determine if the input image is healthy or diseased. If the image is found to be diseased, some existing works have further classified it into a number of diseases. For classification, a software routine is required to be written in MATLAB, also referred to as classifier. A number of classifiers have been used in the past few years by researchers such as k-nearest neighbor (KNN), support vector machines (SVM), artificial neural network (ANN), back propagation neural network (BPNN), Naïve Bayes and Decision tree classifiers. The most commonly used classifier is found to be SVM. Though every classifier has its advantages and disadvantages, SVM is simple to use and robust technique [15].

III. Results and Discussion

The plant disease detection has the three major phases which are features extraction, segmentation and classification. The k-mean segmentation technique is applied for the image segmentation. The GLCM algorithm is the applied for the feature extraction. The technique of classification is applied for the disease name prediction. In the research work, two classification techniques are compared which are SVM and Naïve Bayes for the disease prediction. The results of these two classifiers are compared in terms of execution time and accuracy.

Accuracy

Accuracy is defined as the number of points correctly classified divided by total number of points multiplied by 100

$$\text{Accuracy} = \frac{\text{Number of points correctly classified}}{\text{Total Number of points}} * 100$$

Execution Time

Execution time is defined as difference of end time when algorithm stops performing and start time

Execution time = End time of algorithm- start of the algorithm

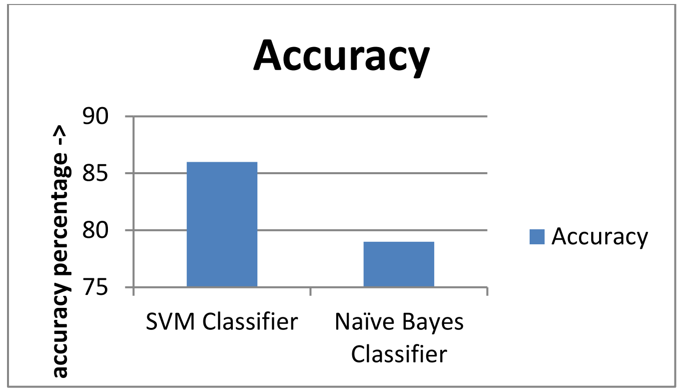

Fig. 2. Accuracy Comparisons

As shown in figure 2, the accuracy of SVM and Naïve Bayes classifiers are compared for the plant disease detection. It is analyzed that accuracy of SVM is more as compared to Naïve Bayes for the plant disease detection

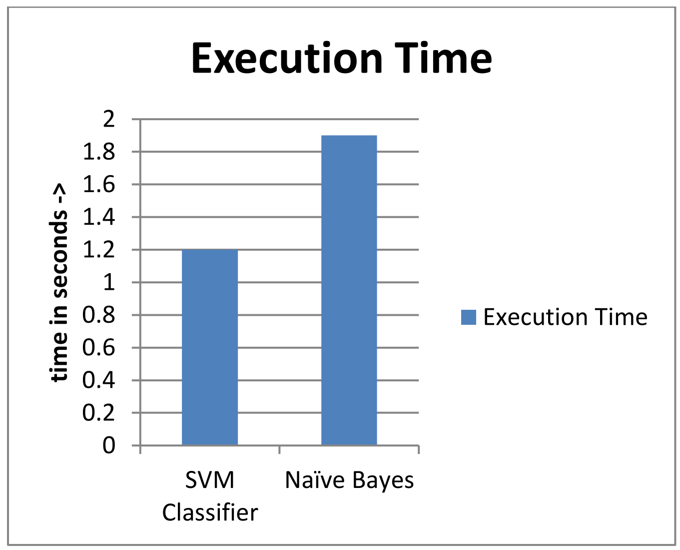

Fig. 3. Execution time

As shown in figure 3, the execution time of SVM and naïve bayes classifiers are compared for the performance analysis. The SVM classifier has less execution time as compared to naïve bayes classifier.

IV. Conclusion

This paper reviews and summarizes various techniques of plant disease detection using image processing that have been used by a number of researchers in the past few years. The major techniques employed were: BPNN, SVM, K-means clustering, Otsu's algorithm, CCM and SGDM. These techniques are used to detect if the leaves are healthy or diseased. Various challenges arise in this process including the automation of the detection system using complex images captured in outdoor lightning and intense environmental conditions. This review paper concludes that these disease detection techniques show a efficiency and accuracy such that they have the ability to run the system developed for detection of leaf diseases besides having some limitations. Therefore, there is a lot that can still be done in this field for enhancement of the existing works.

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