A review on Image Processing Techniques for Plant Leaf Disease Detection and Classification

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Abstract: In Agriculture, leaf diseases have developed to be a predicament as it can cause a significant reduction in both quality and quantity of agricultural yields. Most of the time farmers come across great difficulties in identifying and controlling plant diseases. Thus, it is very important to diagnose the plant diseases at early stages so that proper and suitable action can be taken by the farmers to avoid further loss. The assessment of plant leaf diseases using traditional common eye approach which may be subjective, time-consuming and costly. This is one of the reasons that automatic disease detection in plants leaves plays an important role in the agriculture field. In recent years researchers had developed several algorithms for plant leaf disease detection using image processing and computer vision. Color, morphological and texture features are the most commonly used to detect and classify the diseases of plant leaves. Consequently, these features are used to prepared soft computing methods network. In this paper, use of image processing in agriculture has been reviewed on different image segmentation and classification techniques used for automatic detection as well as classification of plant leaf diseases.

Keywords — Disease detection, Classification, Computer vision, Segmentation, Pattern Recognition, Features extraction

I. INTRODUCTION

During the recent past, agricultural plant disease has become serious threats in India. These diseases can result in significant reduction in both quality and quantity of agricultural yields. The consequence of this is it causes production and economic losses [1]. Most of the time farmers come across great difficulties in identifying and controlling plant diseases. Thus, it is very important to diagnose the plant diseases at early or superior stages so that proper and suitable action can be taken by the farmers to avoid further loss. For existing plant leaf disease identification, the necked eye observation of experts is the main approach adopted in practice. However, this requires continuous monitoring of an agricultural expert, which might be subjective, time-consuming and consulting to very expensive in the large farm [6 12]. Therefore these issues demand automatic and accurate method to detect plant diseases is of great realistic significance [1, 6, 8]. In recent years researchers had developed several algorithms for automatic plant leaf disease detection and classification using image processing and computer vision. There are various applications in agriculture. In the agriculture field, digital image processing techniques have been established as an effective means for analyzing purposes in various applications like plant leaf, stem disease detection, food disease detection , etc.[13].In plant nitrogen identification, image processing is used for estimation of chlorophyll and nitrogen [30]. Image processing technique and computer vision system have been used for automatic detection and classification of plant disease from extracted color, texture and shape features [24]. Studied show that image processing and computer vision tools can be successfully used as automatic and accurate disease detection mechanism [15].

II. IMAGE PROCESSING USING COMPUTER VISION

A. Computer Vision Experimental Set Up

Computer vision is used to collect the information from the images which are taken from the real-time world. It is a tool that includes techniques for 1] image acquisition, 2] image processing, 3] image analyzing, and 4] image understating.

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In order to collect information (e.g., in the form of decision and conclusion). Computer vision is widely used for quality assessment and grading of plant diseases. A computer vision experimental system comprises five components: 1] Light illumination system, 2] Image acquisition system (camera), 3] Image digitizer board.4] Computer hardware and 5] High computational software. Computer vision experimental set up is shown in Fig. 1.

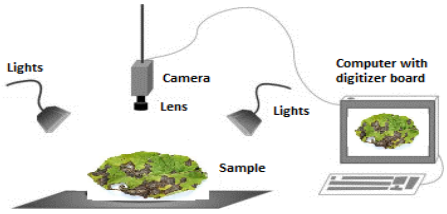

Fig. 1. Elements of computer vision systems.

B. Color Features

It is the most common color model in image processing which is based on primary colors red, green, and blue (RGB). In this stage, every acquired image is chunked into red(R), green (G), and blue channels. Through these channels, various color features such as mean, median, standard deviation etc. are estimated. HSI (Hue, Saturation, and Intensity) and HSV (Hue, Saturation, and Value) are two different depictions of the RGB color model, which is supportive to human visual perception [20].HSV color space express colors, Hue (H) -represents color, Saturation (S) - represent the range of grey in the color space(value is '0,' represent grey and the value is '1,' represent basic color), Value (V) - Value is the brightness which changes with color saturation (value is '0' represent black) by extending values color will brighten. The HSV color space most time, it is used by people to select the desired colors. To select the desired color an HSV color palette is used. Also, there are different color models such as CMYK and YCbCr. But usually, HSI color feature model was preferred because it is the best tool for developing digital image processing algorithms based on the color that is natural and perceived by humans [8, 20, 21, 28].

C. Morphological Features

Morphological features are commonly used for classification of plant leaf by means of shape and size. This uses set of image processing operations that process images based on shapes. Most of the time for identification of plant leaf, shape analysis was done using various techniques such as scale invariant feature transform (SIFT) [2, 22]. This technique matches the key points of the reference image with that of the test image and computes the identical value to find out the correspondence between two images.

Studied shows that basic morphological operators such as dilation, erosion, opening, closing etc. are applied on grayscale image called grayscale morphology [4, 5]. These operations performing different image processing operation over test image which is given hear.1] Dilation: applying dilation operation on grayscale image will enhance brightness of image.2] Erosion: applying erosion operation on grayscale image will reduce brightness of image.3] Opening: this operation eliminate little brighter portion in the image.4] Closing: this operation eliminate little darker region in the image.5] Hat transform: when applying top hat operation it can extract little brighter region and while applying bot hat transform can extract little darker region.

D. Texture features

The texture is an arrangement of the structure with regular intervals. In general, texture refers to surface characteristic and appearance of an object given by the size, shape, density, arrangement, and the proportion of its elementary parts. A basic stage to collect such features through texture analysis process is called as texture feature extraction [31]. There are four major application domains related to texture analysis, 1] texture classification, 2] segmentation, 3] synthesis and 4] shape. 1] Texture classification produces classified output where each region found identical with texture class. 2] Texture segmentation: In this stage partition of an image into a set of disjoint regions based on homogeneity texture properties.3] Texture synthesis: this stage creates large textures from usually small texture samples. A typical process of texture analysis is shown in Fig 2[31].

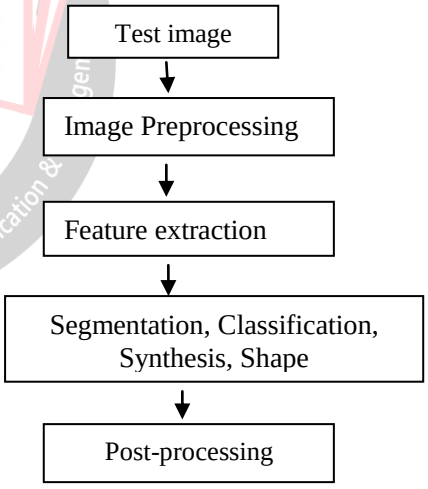

Fig. 2. Process of texture analysis

Usually Texture features can be extracted using statistical, and transform based methods. Statistical method: Statistical methods are used to analyze the spatial distribution of gray values by computing local features at each point in the image and deriving a set of statistics from the distributions of the local features. According to the number of intensity points (pixels) in each combination, statistics are classified into first-order, second order and higher-order statistics. The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second order statistical texture features.
In the transform based feature extraction Gabor transformation method is most commonly used but it is

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having limited use. In this transforming original images by using filters and calculating the energy of the transformed images is take place.

III. Detection and Classification Methods Using Computer Vision

In the present method of eye prediction techniques, there are issues with the efficiency and precision of manual grading system because the results are not accurate and precise and also sometimes this expert advice is most expensive and is not timely accessible to farmer [1, 7].Hence having an automated disease detection with soft computing facilitates a fast, consistent and convenient way of detecting leaf diseases on plant leaves [22]. A plant leaf disease with accurate disease detection is based on color, size, shape, and texture of the leaves.

Extensive research has been conducted to explore various methods for automated identification of plant diseases. Some of developed systems in this area are explained below:

Dheeb Al Bashish, Malik Braik, Sulieman [1], proposed a framework for detection of plant diseases present on leaves and stem. The proposed framework is composed of K-Means segmentation technique and the segmented images are classified using neural network classifier. The classification showed an average accuracy of 93%. Anand R. S, Aravinth J [2] presented work to diagnose the disease of brinjal leaf using image processing and artificial neural techniques. The leaf spot disease is considered in this work and it is found that method successfully identify the disease using k-means clustering algorithm and ANN. He had computed various parameters such as Area, Perimeter, Centroid, Diameter and Mean Intensity for identifying brinjal diseases. Yogesh Dandawate, Radha Kokare [3] proposed technique used for automated plant diseases classification based on leaf image processing. His research work is concerned with the discrimination between diseased and healthy soybean leaves using SVM classifier and classification showed an average accuracy of 93.79%. For this research work, he had tested their algorithm over the database of 120 images. Also, he found that the SIFT algorithm correctly recognize the plant species based on the leaf shape.

Juan F. Molina, Rodrigo Gil, Carlos Bojaca, Francisco Gómez and Hugo Franco [4] present a Computer Vision prototype system for the automatic detection of mycotic infections on tomato crops. This system is based on the characterization of tomato leaflets for that he had considered both healthy and early blight– infected regions of interest – (ROIs). For experimentation, he used nearest neighbor classifier for simple representation of color data, together with and he came with the conclusion that color structure descriptor (CSD) approach, be the better choice to represent color features.

Dhiman Mondal, Dipak Kumar Kole [5] proposed a method to detect and classify the presence of yellow vein mosaic virus disease of okra leaf with the aid of K-means and Naive Bayesian classifier. He has experimented on 79 standard diseased and non-diseased okra leaf images. Classification showed an average accuracy of 87%.

Preetha Rajan, Radhakrishnan. B. and Dr.L.Padma Suresh [6] presents automatic pest identification system in which color feature is used to train the SVM to classify the pest pixels and leaf pixels. Also, he had used several morphological operations to remove the unwanted elements in the classified image. Vijai Singh, Varsha and Prof. A K Misra [7] presents a genetic algorithm for image segmentation technique used for automatic detection as well as classification of plant leaf diseases also he had done extensive literature survey on different plant leaf diseases detection and classification techniques.

Mrunmayee Dhakate [8] proposed an image processing and neural network methods for disease detection and classification. For experimentation, he used pomegranate fruit as well as the leaves which are affected by various diseases caused by fungus, bacteria etc. In this work he had applied some image pre-processing techniques followed by k-means clustering segmentation. Then he had taken texture features which are extracted by using GLCM method and given to the artificial neural network. Classification showed an average accuracy of 90%. Aditya Parikh [9] present two cascaded classifiers. First classifier segments leaf from the background using local statistical features. Then using hue and luminance from HSV color space second classifier is trained to detect grey mildew disease and find its stage.

Noa Schor [10] proposed robotic systems for disease such as Powdery mildew (PM) and tomato spotted wilt virus (TSWV) detection in greenhouses. The Study revealed that developed detection algorithms which are based on the principal component analysis (PCA) and the coefficient of variation (CV) successfully classified above diseases with an accuracy of (90%). A Meunewjinda [11] presents automatic grape leaf disease detection using multiple artificial intelligence techniques. The proposed system consists three main parts 1] grape leaf color segmentation 2] grape leaf disease segmentation and 3] analysis and classification of diseases. Grape leaf color segmentation segment out unwanted background information and extracted its color features using back propagation neural network model. For grape leaf disease segmentation genetic algorithm is applied with SVM classifier to analyze disease features. Sanjeev S Sannakki [12] presents using image processing and artificial intelligence techniques for detection of diseases of the grape plant leaf. For experimentation with the proposed system, grape leaf image with a complex background is taken as input then thresholding applied to mask green pixels and then grape leaf disease segmentation is done using K-means clustering.

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He gets very good results using feed forward back propagation neural network classifier

Baldomero Manuel at al [13] present image processing method to diagnose and classify grapevine leaves with a certain level of potassium deficiency is proposed. He proposed K-Nearest Neighbors (KNN) segmentation method and then compared to methods based on the histogram. He found that KNN techniques give better results especially when the environments were images are acquired is less controlled.

Aakanksha Rastogi [14] proposed a system using image processing system which includes pre-processing of leaf images, and feature extraction followed by Artificial Neural Network based training and classification for recognition of leaf. For detection of the disease present in the leaf using K-Means based segmentation techniques in which infected area is extracted, feature extraction of defected portion using ANN based classification technique was done. Then the disease grading is done on the basis of the amount of disease present in the leaf.

Pratheba.R [15] proposed comparison performance of clustering based image segmentation methods such as K-Means and Fuzzy C-Means clustering algorithm. He measured the performance of these algorithms using various segmentation parameters such as PSNR, SC, NK, NAE and AD. Study revealed that the K means image segmentation method is time efficient but it provides poor result in performance analysis. While the conventional FCM algorithm is time inefficient but it provides a good result. Therefore from this experimental results author concluded that the FCM algorithm performs better than K means algorithm in terms of performance measures and better convergence rate.

Rajat Kanti Sarkar [16] presents seeded region growing (SRG) algorithm for colored images. He proposes a novel two-dimensional look-up table for labeling the neighbors for region merging. For experimental work, author implements algorithm first in the YCbCr color space and then he tried for other color spaces like YCbCr, CIELAB, and RGB to validate the best performance of the segmentation algorithm. Study raveled that the SRG algorithm along with the proposed modification for region merging gives good results in the YCbCr color space compared to other color spaces for plant leaf disease segmentation.

Evy Kamilah Ratnasari [17] proposes a model to identify the severity of spot disease which appears on leaves. He used thresholding a* component of L*a*b* color space for disease spot detection. Then features of diseases spots are extracted using Support Vector Machine (SVM) classification techniques, first he uses L*a*b* color space for its color features and then applied Gray Level Co-Occurrence Matrix (GLCM) to obtain texture features. Study revealed that proposed model is capable to determine the types of spot diseases with an accuracy of 80% and 5.73 error severity estimation average.

Bhumika S. Prajapati [18] present extensive survey on detection and classification of cotton leaf diseases. For experimentation work, he proposed image processing and machine learning techniques in order to identify the cotton leaf diseases accurately. He applied certain techniques for removal of background and then image segmentation is done using Otsu thresholding technique. Various segmented images considered for extracting the features such as color, shape, and texture from the images. Then these extracted features applied at inputs of a classifier.

Pranjali B. Padol [19] present automatic detection and classification system for leaf diseases of grape using SVM classification technique. For disease region segmentation author uses K-means clustering technique, then both color and texture features are extracted. Study revealed that the proposed system can successfully detect and classify the examined disease with an accuracy of 88.89%.

Usama Mokhtar [20] present method using Gabor wavelet transform technique to extract relevant features related to the image of tomato leaf with the aid of Support Vector Machines (SVMs) in order to detect and identify the type of disease that infects tomato plant. He applied a support vector machine classier with different kernel functions such as Cauchy kernel, and Laplacian Kernel which was employed to evaluate the ability of this approach to detect and identify where tomato leaf infected with Powdery mildew or early blight. He experiments over 100 images of data set for each type of tomato diseases. A study revealed the proposed approach provides excellent annotation with accuracy 99.5 %.

Ms. Kiran R. Gavhale [21] proposed framework model into four parts 1] image preprocessing including RGB to different color space conversion, 2] image enhancement; 3] disease region segmentation using K mean clustering. Statistical features used determine the defection of disease and severity areas of plant leaves. Then color feature extraction by mean of mean values and texture feature extraction using statistical GLCM. Classification is done using SVM.

Dr.Sanjay B. Patil [22] proposed the Triangle threshold and simple threshold methods. These methods are used to lesion region area and segment the leaf area respectively. In the final step, categorization of disease is done by calculating the quotient of leaf area and lesion area. Study revealed that, the given method is fast and accurate for calculating leaf disease severity and leaf area calculation is done by using threshold segmentation.

Mrs. Jayamala k. Patil [23] present extensive survey on advances in various methods used to study plant diseases/traits using image processing. The author suggests

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that the methods studied are for increasing throughput and reducing subjective bias arising from human experts in detecting the plant diseases. Mohammad el- Helly [24] presents a novel approach for integrating image analysis technique into the diagnostic expert system. He applied four phases of image processing techniques to get result 1] enhancement 2] segmentation 3] feature extraction and 4] classification.

S. Arivazhagan [25] present system for automatic detection and classification of plant leaf diseases. This system consists of four main steps, first a color transformation structure for the input RGB image is created, second, a specific threshold value followed by segmentation process, third the texture statistics are computed for the useful segments, and fourth extracted features are passed through the classifier. Study revealed that proposed algorithm's efficiency can successfully detect and classify the examined diseases with an accuracy of 94%.

Piyush Chaudhary [26] proposed an algorithm for disease spot segmentation using image processing techniques in plant leaf is implemented. Author present comparative of the CIELAB, HSI and YCbCr color space in the process of disease spot detection is done. He also uses the median filter for image smoothing. For segmentation threshold value estimated by applying Otsu method on a color component to detect the diseased spot.

Jayme Garcia [27] presents a new method for measuring the areas occupied by early and late leaf spots; an author uses well-known mathematical morphology operations for disease detection. A study shows that the proposed method performs as well as semi-automatic and manual methods, being, at the same time, much more practical and faster. The brief summary of the literature described above has been tabulated in Table 1.

Table 1. Review of Disease Detection Techniques

References	Segmentation Technique	Classification Technique	Efficiency
Dheeb Al Bashish. [1]	K-Means	Artificial Neural Network (ANN)	93%
Anand R, [2].	K-Means	Artificial Neural Network (ANN)	90%
Yogesh Dandawate [3]	SIFT	Support Vector Machine (SVM)	93.79%
Dhiman Mondal [5]	K-Means	Bayesian classifier	87%
Mrunmayee Dhakate [8]	K-Means	Artificial Neural Network (ANN)	90%
A Meunewjinda [11]	Genetic Algorithm	Support Vector Machine (SVM), and Back Propagation Neural Network	90%
Evy K. Ratnasari [17]	Thresholding	Support Vector Machine (SVM),	80%
Pranjali B. Padol [19]	K-Means	Support Vector Machine (SVM),	88.89%
Usama Mokhtar [20]	Thresholding	Gabor wavelet transform and Support Vector Machine (SVM),	99.5%
S. Arivazhagan [25]	Thresholding	Support Vector Machine (SVM),	94%
S. B. Jadhav et al. [32]	K-Means	NA	NA

IV. CONCLUSION

In this paper, various image processing based detection and classification techniques for plant leaf disease detection is reviewed. Computer vision based plant leaf disease detection system is capable of replacing present open eye expert prediction method for amassment and grading disease. Amongst color, texture and morphological feature, morphological gave highest efficiency rate. In color model, (HIS) is commonly used for plant leaf disease detection because of its relation to human eye perception. In detection techniques, K-Means segmentation algorithm gave optimum results with very less time and computational efforts, which also shows the efficiency of the proposed algorithm in detection and classification of leaf diseases. In classification models, SVM (Support Vector Machine) gave highest efficiency further model gave lowest efficiency rate in the result.

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