Unhealthy Region of Citrus Leaf Detection Using Image Processing Techniques

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Abstract— **Producing agricultural products are difficult task as the plant comes to an attack from various micro-organisms, pests and bacterial diseases. The symptoms of the attacks are generally distinguished through the leaves, steams or fruit inspection. The present paper discusses the image processing techniques used in performing early detection of plant diseases through leaf features inspection. The objective of this work is to implement image analysis and classification techniques for extraction and classification of leaf diseases. Leaf image is captured and then processed to determine the status of each plant. Proposed framework is model into four parts image pre-processing including RGB to different color space conversion, image enhancement; segment the region of interest using K-mean clustering for statistical usage to determine the defect and severity areas of plant leaves, feature extraction and classification. texture feature extraction using statistical GLCM and color feature by means of mean values. Finally classification achieved using SVM. This technique will ensure that chemicals only applied when plant leaves are detected to be effected with the disease.**

Keywords: citrus; canker; anthracnose; co-occurrence matrix; SVM; texture feature.

I. Introduction

Agriculture is the mother of all cultures. It has played an important role in the development of human civilization. The focus on enhancing the productivity, without considering ecological impacts has resulted into environmental degradation. Without any adverse consequences, improvement of the productivity can be done in a sustainable manner. Plants exist everywhere we live, as well as places without us. Lots of them carry significant information for the development of human society. As diseases of the plants are inevitable, detecting disease plays a major role in the field of Agriculture [1]. Plant leaf disease is one of the crucial causes that reduces quantity and degrades quality of the agricultural products. Currently chemicals are applied to the plants periodically without knowing the requirement of plants.

Common symptoms are includes abnormal leaf growth, color distortion, stunted growth, shriveled and damaged pods. Although diseases and insect pests can cause considerable yield losses or bring death to plants and it's also directly affect to human health. These require careful diagnosis and timely handling to protect the crops from heavy loses [2]. In plant, diseases can be found in various parts such as fruit, stem and leaves. Leaf presents several advantages over flowers and fruits at all seasons worldwide [3, 4].

This enables machine vision to provide image based automatic detection and guidance. This paper is organized into the following sections. Section 1 gives an introductory part and importance of leaf disease detection. Section 2 describes various types of leaf diseases and its symptoms. Section 3 presents a detailed discussion on recent work carried out in this area. Section 4 includes proposed methodology for leaves disease extraction and classification which represents a brief review on various image processing techniques. Section 5 shows experimental result. Finally, Section 6 concludes this paper along with possible future directions.

II. Plant diseases analysis and its symptoms

Proposed work focusing on citrus trees which include grapefruit, lemons, limes and oranges leaf attack by various citrus diseases. Some citrus leaves diseases and it's symptoms as shown below:

A. *Citrus canker*

Citrus canker is spread by wind driven rain. Typical citrus canker lesions on plant leave having range from 2-10 mm in size and seem as concentric circles on the underneath of the leaf. Often lesions will be encircled by a water-soaked margin and yellow color halo. As canker lesion matures, it may lose it palpable roughness but concentric circles still visible. The yellow halo eventually changes to dark brown or black color. Water-soaked edge adjoining the lesion may

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reduce as shown in fig.1 (a). The middle of the lesion will be rough in texture with a pimple-like point. Always found in both sides of the leaf with the exception of very young lesions.

B. Anthracnose

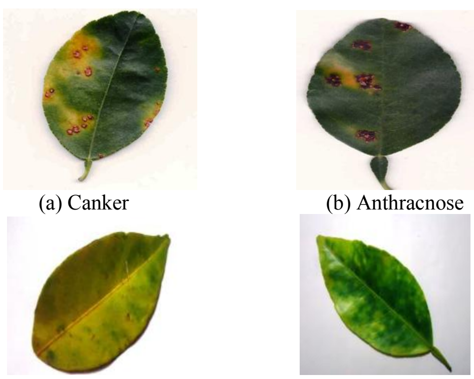
Anthracnose is a key colonizer of injured and senescent tissue. The micro-organism grows on lifeless wood in the canopy, and then spreads short distances by heavy dew, rain splash, and overhead irrigation. Common symptoms are a more or fewer circular, flatted area, light tan in color with a prominent purple margin as shown in figure 1(b).

C. Overwatering

IT is another cause of unhealthy leaves due to overwatering. Large amount of water can cause curl leaves, turn yellow color and drop as shown in fig.1(c).

D. Citrus greening disease

Leaves with yellow veins formation is the most characteristic symptom of citrus greening disease. Some times look like leaf deficiency as shown in fig.1 (d).



(a) Canker (b) Anthracnose

(c) Overwatering (d) Citrus Greening

Fig. 1. Citrus leaves diseases

III. LITERATURE REVIEW

A Proliferation of literature is available in plant leaf disease detection. We will highlight some of the key contributions.

A methodology for detecting plant diseases early and accurately using diverse image processing techniques has been proposed by Anand H.Kulkarni *et al.* [1], in which Gabor filter has been used for feature extraction and ANN based classifier has been used for classification with recognition rate up to 91%. F. Argenti, *et al.* [2] proposed a fast algorithm for calculating parameters of co-occurrence matrix by supervised learning and maximum likelihood method for fast classification. Homogenize techniques like canny and sobel filter has been used to identify the edges by P.Revathi *et al.* [3]. Then these extracted edge features have been used in classification to identify the disease spots. Proposed homogeneous pixel counting technique for cotton diseases detection (HPCCDD) algorithm has been used for categorizing the diseases. They claim the accuracy of 98.1% over existing algorithm. Tushar H Jaware *et al.* [4] proposed a novel , improved k-means clustering technique to solve low-level image segmentation. Spatial gray-level dependence matrices (SGDM) method has been used for extracting statistical texture features by Sanjay B. Dhaygude *et al.* [5] also RGB images have been converted into Hue Saturation Value (HSV) color space representation and showed the H, S and V components. Mokhled S. Al-Tarawneh [6] presented an empirical investigation of olive leaf spot disease using auto-cropping segmentation and fuzzy c-means classification. RGB to LAB color space and median filter used for image enhancement. At end present comparative assessment of fuzzy c-means and k-mean clustering.

S.M.Ramesh, *et.al*.[7] proposed new technique for enhancement of color images by scaling the discrete cosine transform coefficients. Provides better enhancement compared to image capture by digital camera if resolution improper. Back-propagation (BP) networks have been used to classify the grape and wheat diseases by Haiguang Wang *et al.* [8]. Also principal component analysis (PCA) has been used to reduce dimensions of the feature data. A. Menukaewjinda *et al.* [9] tried another ANN, i.e. back propagation neural network (BPNN) for efficient grape leaf color extraction with complex background. They also explore modified self organizing feature map (MSOFM) and genetic algorithm (GA) and found that these techniques provide automatic adjustment in parameters for grape leaf disease color extraction. Support vector machine (SVM) has been also found to be very promising to achieve efficient classification of leaf diseases. Detection of unhealthy region and classification using texture features has been proposed by S. Arivazhagan, *et al.* [10]. Their algorithm has been tested on ten species of plants namely banana, beans, jackfruit, lemon, mango, potato, tomato and sapota. 94.74% accuracy has been achieved by Support vector machine (SVM) classifier.

A Research of maize disease image recognition of corn based on BP networks effectively identified by Song Kai *et al.* [11] where YCbCr color space technology is used to segment disease spot, Co-occurrence matrix (CCM) spatial gray level layer is used to extract disease spot texture feature, BP neural network has been used to classify the maize disease. The applications of K-means clustering as well as BP neural networks had been formulated for clustering and classification of diseases that affect on plant leaves by H. Al-Hiary, *et al.* [12]. They provide adequate support for accurate detection of leaf diseases.

IV. PROPOSED METHODOLOGY

There are five main steps used for the detection of plant leaf diseases as shown in fig.2. The processing scheme consists of image acquisition through digital camera or

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scanner, image pre-processing includes image enhancement, image segmentation where the affected and useful area are segmented, feature extraction and classification. Lastly the presence of diseases on the plant leaf will be identified. Here we present step by step approach for segment the diseased image and extract its features.

A. Image Acquisition

Firstly, the images of various leaves acquired using a digital camera with required resolution for better quality or by scanner. The input photo image is then resized to 256x256 pixels. The construction of an image database is clearly dependent on the application. The image database itself is responsible for the better efficiency of the classifier which decides the robustness of the algorithm.

B. Image Pre-processing

Image pre-processing is the lowest level of abstraction whose aim is to improve the image data that suppress undesired distortions as well as enhances some image features which is important for further processing and analysis task. It includes color space conversion and image enhancement.

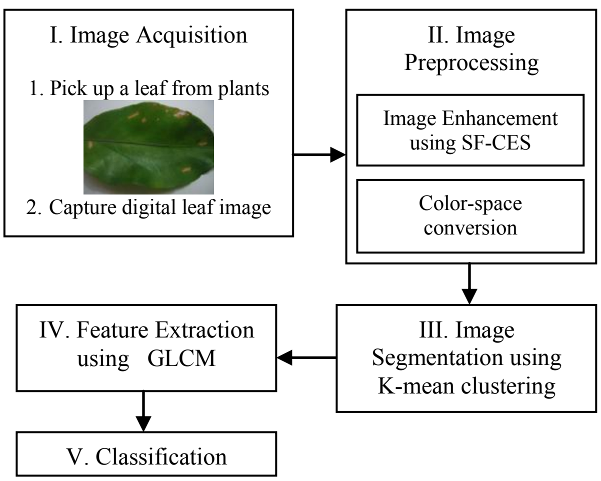

Fig. 2. Proposed Methodology

1) Image enhancement: Direct observation of color images is often strikingly different as human visual perception computes the conscious representation. A simple approach in the block (DCT) Discrete Cosine Transform domain for enhancing color images by scaling the transform coefficients i.e. color enhancement by scaling (SF-CES) .

The unique feature is that it uses chromatic and luminance component which improves the visual quality of the images to a great extent. It provides better enhancement for color images as shown in fig.3. There are also other advantages for using this algorithm such as adjustment of local background brightness by scaling DC coefficients, preservation of local contrast by scaling DC and AC coefficients, preservation of color by Scaling DC and AC coefficients using function including all three colors information [7].

a) Original image b) CES Ehnhanced

Fig.3. Image Enhancement using CES

2) Colorspace conversion: This block play important role in leaf spot detection because it defines the needed color transformation that will be used in cluster separation. The RGB images of citrus leaf are converted into color space representation. The principle of color space is to facilitate the specification of colors in some standard, generally accepted way.

There are various color space available such as CIELAB, Ycbcr, HSV. Color transformation determines the luminosity and chromaticity layers which classify colors according to human vision system and that very useful in subjective analysis of leaf images judgment. RGB is an ideal for color generation while HSV model is an ideal tool for color perception [5]. Hue is a color attribute that describes pure color as perceived by an observer. Saturation refers to relative purity or the amount of white light added to hue. Value means amplitude of light.

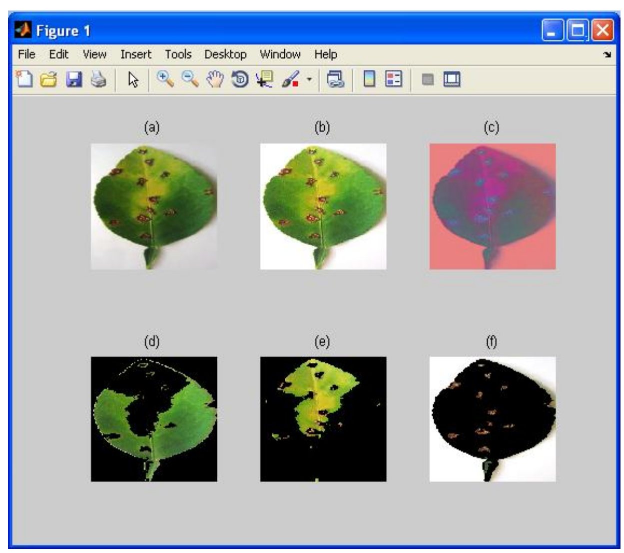

Figure 4: An example of K-Means clustering output for a citrus leaf that is infected with anthracnose disease. (a) Original image , (b) Enhanced image, (c) Ycbcr color space conversion, (d, e, f) pixel of the first cluster shows green part of leaf while second and third clusters shows disease part respectively.

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a) *YCbCr :* YCbCr color system is a common color system used here which is applied by the most widely used JPEG image as well as for digital video. In this color space system, luminance information is stored as a single luminance component 'Y', and chrominance information is stored in two color-difference components i.e. Cb and Cr. Where Cb represents the difference between blue component and reference value. Cr represents the difference between red component and a reference value. It is used in bandwidth reduction, sub sampled, and also treated separately for improved system efficiency [12]. RGB color transformation into YCbCr implemented and the result as shown in fig.4.

b) *L*a*b* :* L*a*b* color space chosen due to the uniform distribution of colors as it visualize same as human perception of color [6]. It consists of a luminosity layer 'L*', chromaticity layer 'a*' represents red-green axis and chromaticity-layer 'b*' represents where the color place along the blue-yellow axis. RGB color transformation into L*a*b* implemented and the result as shown in fig. 5.

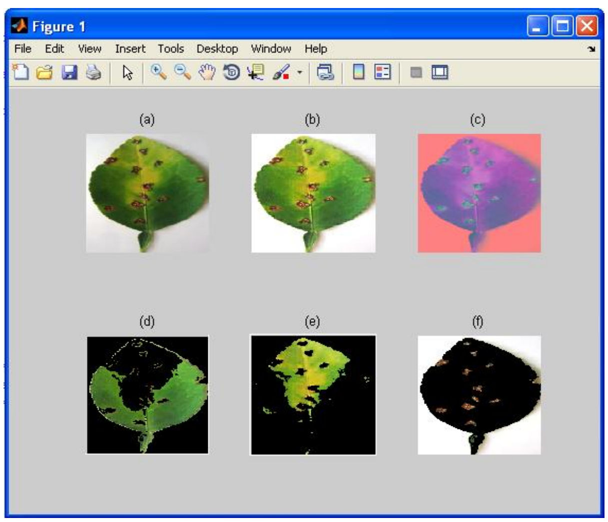

Figure 5: An example of K-Means clustering output for a citrus leaf that is infected with anthracnose disease. (a) Original image , (b) Enhanced image, (c) LAB color space conversion, (d, e, f) pixel of the first cluster shows green part of leaf while second and third clusters shows disease part respectively.

C. Image Segmentation

Image segmentation is process used to simplify the representation of an image into something that is more meaningful object of interest from background and easier to analyze. Segmentation is also done through feature based clustering [8]. Basic clustering k-means algorithm is used for segmentation in textured images [6].Creating device-independent color space conversion as discussed in previous phase in which coordinates used to specify the color.

The K-means clustering algorithm used to classify pixels based on a set of features [4, 12]. The classification achieved by minimizes the sum of squares of distances of the objects and the corresponding cluster. However, K-means clustering is used to separate the leaf image into different clusters if a leaf contains more than one disease. The suitable color group numbers lead to the better color extraction [9]. An example of K-Means clustering output for a leaf infected with citrus anthracnose disease shown in fig. 4, 5, and 6 with different color space.

It is observed from figure 5 and 6 where cluster 1 and 2 contains infected object of canker anthracnose disease and clusters 3 contain green part of leaf using Ycbcr and Lab color space.

D. Feature Extraction

After segmentation the area of interest i.e. diseased part extracted. The aim of this phase is to find and extract features that can be used to determine the meaning of a given sample. Image features usually include color, shape and texture features in image processing [2]. Texture is one of most popular features for image classification and retrieval. Currently most of the researchers targeting plant leaf texture as the most important feature in classifying plants.

In this part, we present a statistical method using GLCM. This method allows computing some statistics describing texture. In this section, different statistics used to describe texture after construction of the GLCMs present.

*Gray-Level Co-Occurrence Matrix (GLCM) :*GLCM is the statistical method of investigative texture which considers the spatial relationship of pixels [10]. The GLCM functions characterize the texture of a leaf image by calculating occurrence of pixel in an image with specific values and in a specified spatial relationship. By creating a GLCM followed by extracting statistical measures from this matrix.

Gray-Level Co-Occurrence matrix creation : Graycomatrix function creates a gray-level co-occurrence matrix (GLCM) by calculating occurrence of a pixel value i with the pixel value j in a specific spatial relationship.

Specifying the Offsets: To create number of GLCMs, have to specify an array of offsets. Offsets describe pixel relationships of varying direction and distance such as four directions viz. horizontal, vertical, two diagonals and four distances. Represent these offsets as integer's p-by-2 array. Each row in an array is a two-element vector i.e. [row_offset, col_offset].

Derive Statistics from a GLCM: Here, statistics derived from GLCMs using the graycoprops function. Hence, we will see statastics viz. contrast, energy, homogeneity and entropy [5, 11].

1) Contrast: Contrast measures intensity contrast of a pixel and its neighbor pixel over the entire image. If the image is constant, contrast is equal to 0 while the largest value can be obtained when the image is a random intensity image while that neighbor intensity and pixel intensity are very different. Equation of the contrast is as follows:

$$Contrast = \sum_{i,j=0}^{N-1} P_{ij} (i-j)^2$$

2) Energy: Energy is a measure of uniformity with squared elements summation in the GLCM. Range is in between 0 and 1. Energy is 1 for a constant image. The equation of the energy is shown:

$$Energy = \sum_{i,j=0}^{N-1} \left(P_{ij}\right)^2$$

3) Homogeneity: Homogeneity measures the closeness of the distribution of elements towards the diagonal in the GLCM. It's range in between 0 and 1. Homogeneity is 1 for a diagonal GLCM. The equation of the contrast is as follows:

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1+(i-j)^2}$$

4) Correlation: Correlation measures how correlat a pixel to its neighbor pixel over the whole image. Range is in between -1 and 1.

$$Correlation = \sum_{i,j=0}^{N-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2}$$

Where ,
P_{ij} = Element i,j of the image
N = Number of gray levels

μ = mean value of all pixels in the relationships that contributed to the GLCM, it is calculated as:

$$\mu = \sum_{i,j=0}^{N-1} iP_{ij}$$

Б ^{2} = variance of the intensities of all reference pixels calculated as:

$$\sigma^2 = \sum_{i,j=0}^{N-1} P_{ij} (i-\mu)^2$$

RGB representation of image is used for color textures features extraction. Features vector (FV) is computed by features extraction (FE) for every R (Red), G (Green) and B (Blue) color channel.

E. Classifier

The Support Vector Machine (SVM) classifiers differentiate citrus leaf disease i.e. canker and anthracnose. It constructs a hyper plane in a high dimensional space that can be used for classification. Good separation is achieved by the hyper plane that has the largest distance to the nearest training data point. In general larger the margin lowers the generalization error of the classifier. The feature vector is given as input to the classifier. This method differentiates and identifies the citrus canker and citrus anthracnose. Classification and recognition randomly divide database for training and testing. Both subsets have the random samples from the same distribution. Training dataset consist of 200 sample images of both citrus leave i.e. canker and anthracnose and testing dataset consist of 50 images of each disease sample. The classifier train on the training set applies it to the testing set and then measure performance by comparing the predicted labels and give decision as canker and anthracnose as shown in fig.7.

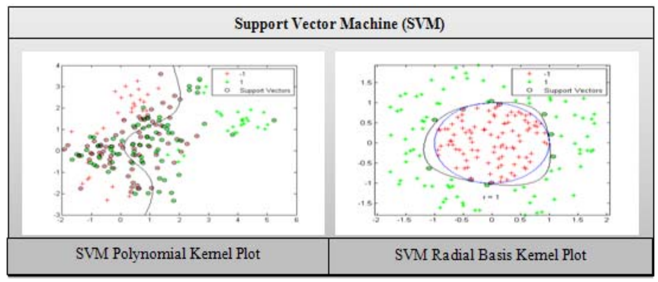

Fig.7. Classifier types

V.EXPERIMENTAL RESULTS

TABLE I. TRAINING AND TESTING SET

Classifiers	No. of images used for training	No. of images used for testing	Total
SVMRBF	200	100	300
SVMPOLY			

TABLE II. FAR, FRR AND GAR RATE

Classifiers	FAR%	FRR%	GAR%
SVMRBF	4%	3%	96%
SVMPOLY	5%	6%	95%

The reference citrus leaf images database is created and on that database different classification techniques are applied such as support vector machine (SVM) with radial basis kernel and polynomial kernel and several experimental results are obtained. The different training and testing samples are used while performing training and testing using classifier mention in table-II and the accuracy of the system is based on the performance evaluation parameter i.e. false acceptance rate (FAR) is 4%, false recognition rate (FRR) is 3% and the genuine acceptance rate (GAR) is 96% for the SVMRBF classifier. The false acceptance rate (FAR) is 5%, false recognition rate (FRR) is 6% and the genuine acceptance rate (GAR) is 95% for the SVMPOLY classifier.

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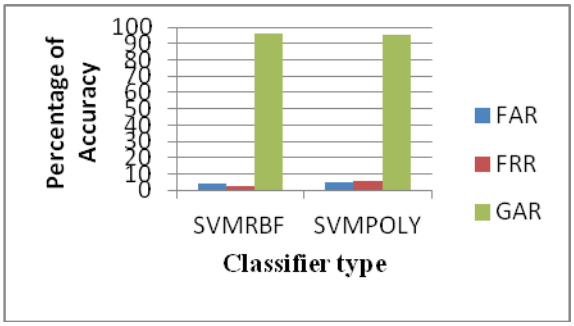

Fig. 8. Graph for the classification accuracy

VI. CONCLUSIONS

This paper presents a number of image processing techniques to extract diseased part of leaf. SF-CES provides better enhancement of color image, Lab and Ycbcr color space supports K-mean clustering for disease part extraction through the means of clusters. Then GLCM texture feature and color textures features are extracted for further classification purpose. Finally classification based on SVM.

With this method, the use of harmful chemicals on plants can be reduced and hence ensure a healthier environment. We should make further research on test equipment, image processing and analysis method to achieve better detection accuracy with different plant species.

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