Plant Disease Diagnosis System for Improved Crop Yield

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Abstract- Identification of the symptoms of plant diseases by means of image processing techniques is of prime concern in the area of research. There is a need for a plant disease diagnosis system that may support farmers during their daily struggle against disease outbreaks. The proposed work is a development of an efficient diagnosis system that focuses on plant disease identification by processing acquired digital images of leaves of the plant. These images are made to undergo a set of preprocessing methods for image enhancement. The enhanced image is segmented using k-means and thresholding based segmentation approaches to extract the region of interest i.e., diseased portion. Later, a satisfying set of visual features from the region of interest are extracted by applying first-level Haar Wavelet Transform method for detecting diseases accurately. Based on the extracted features set, a Fuzzy Logic based classifier identifies the type of the disease being occurred. Finally, treatment measures are provided to control the disease. The advisory helps farming community in effective decision making to protect their crop from diseases and increase its productivity. Thereby, the proposed approach improves crop yield and uplifts the economy of farming community.

Keywords – Image Acquisition, Image Pre-processing, Segmentation, Feature Extraction, Classification, Disease Diagnosis

I. INTRODUCTION

Agriculture production is the means to feed ever growing populations and is the major source of income for the rural poor especially in India where farmers are called "the backbone of India". Plants are the primary source to solve the problem of global warming. It is well understood that threats by invasive pathogens to plants, including crops, horticultural commodities, forests and grasslands, are increasing as a result of globalization, increased human mobility and meteorological impact. The damage caused by emerging, re-emerging, epidemic and endemic pathogens, is significant in plant systems and leads to potential loss economically. In addition, crop failures contribute directly to malnutrition and indirectly to the spread of human infectious diseases and environmental damage. Plant diseases are spreading worldwide dramatically causing impairment to the normal functioning of the plant and are becoming one of the major reasons for financial degradation by significantly reducing the quantity of crops grown. There is a need for systems that can help crop producers and farmers to identify early symptoms of plant diseases by analyzing digital images of crop samples. The identification of the visual symptoms of plant diseases by means of a machine vision system may support farmers during their daily struggle against disease outbreaks. This heads the research towards development of an intelligent decision support system for identifying plant diseases and providing requisite treatment measures for disease control.

Plant disease diagnosis is the determination of the cause of a disease in a plant, and detection refers to the identification of microorganisms or their products, such as toxins in plant tissues, soil, and water. Failures in pathogen detection and disease diagnosis lead directly to inadequate disease control and reductions in crop production and quality, and hence trade. When plants are affectionate to diseases, they display a range of visual symptoms such as colored spots, or streaks that can occur on the leaves, stems, and seeds of the plant. These visual symptoms continuously change their color, shape and size as the disease progresses. In most of the cases, identifying diseases relying only on symptoms with bear eye observation is prone to error and misleads crop growers. Therefore, automatic foliar disease identification by visual inspection can be of great benefit to farming community.

II. RELATED WORK

There are various researchers who have taken their steps into plant disease identification by applying various image processing and machine learning techniques in agriculture and making their mark. The study by Camargo et. al. [1] describes an image-processing based method that identifies the visual symptoms of plant diseases from the analysis of colored images. The algorithm starts by converting the RGB image into the H, I3a and I3b color transformations. The transformed image is then segmented by analyzing the intensity distribution. Once the image is segmented, the extracted region is post-processed to remove those pixels that are not considered as part of the target region. An accurate and automatic method based on image processing and Support Vector Machine is developed [2] to detect three rice diseases viz., Rice Bacterial Leaf Blight (RBLB), Rice Sheath Blight (RSB) and Rice Blast (RB) using image processing and Support Vector Machines (SVM). Grape leaf diseases are identified [3] by deploying Self Organizing Feature Map (SOM) together with Back Propagation Neural Network (BPNN) for color image segmentation and disease classification using SVM. D.N.D.Harini et. al. [4] have proposed an efficient approach for diseased leaf image retrieval based on wavelets and Principal Component Analysis (PCA) techniques and thus identifying the type of the disease. The main concentration in this method is to identify the leaf part which is affected by a disease and identify it. Dheeb Al Bashish et. al. [5] have proposed an image processing based software solution for automatic leaf disease detection and classification. Authors have noted that the naked eye observation for continuous monitoring of crops by experts for disease detection is very expensive and time consuming as well. This task becomes more hectic if farmers have to go long distances to contact trained raters to dig up information. To overcome these drawbacks, authors have proposed a leaf disease identification system tested on five different diseases affecting various plants namely, Early Scorch, Cottony Mold, Ashen Mold, Late Scorch and Tiny Whiteness. This approach begins with device-independent color space transformation of acquired images, followed by k-means based segmentation. Texture features of segmented images are extracted and fed as input to the neural network classifier for diseases classification. An attempt to identify various diseases affecting rice plants is carried out in [6] using image growing, image segmentation and SOM methods. Otsu's thresholding based method is employed in [7] for extracting the diseased portion of the leaf image. Studies show that various image processing and machine learning techniques may be successfully applied in the field of agriculture for early identification of plant diseases.

The proposed approach aims to develop an efficient plant disease diagnosis system that successfully recognizes the foliar disease spots, if any and classifies it into appropriate category considering pomegranate fungal leaf spots namely, Alternaria Leaf Spot (ALS) and Cercospora Leaf Spot (CLS) as case studies. The system also aims to develop a treatment advisory where in disease control measures are provided to end users, farmers in this case, based on the classification results.

III. PROPOSED METHODOLOGY

Figure 1 shows the block diagram of the proposed application and is followed by the detailed explanation of the algorithms used in each phases of the system developed.

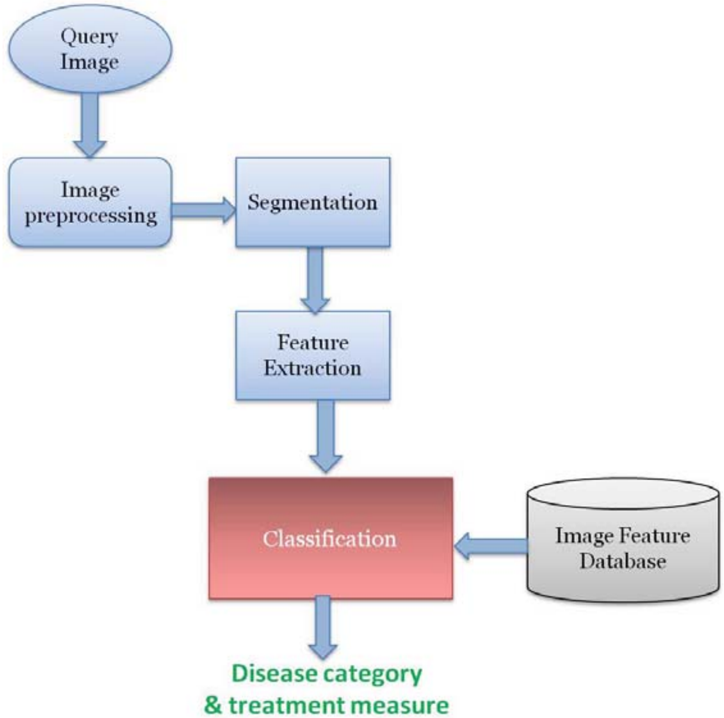

Figure 1. Block Diagram

A. Image Acquisition

Images of pomegranate leaf samples are acquired from National Research Center on Pomegranate, Solapur, Maharashtra, India under the supervision of expert pathologists. These images make the repository required for system development. All the images are stored in JPEG format for keeping uniformity.

B. Image Pre-processing

This module includes two preprocessing phases: image resize and image filtering respectively. All the acquired images are resized to a standard resolution of [512 512] maintaining image quality unaltered. Resized images are filtered to remove any noise content present in the image. Here, a rotationally symmetric Gaussian Low Pass filter is applied with a size of [3 3] and a positive standard deviation sigma of 0.5. Gaussian function at every point on the image will be non-zero. This is important because all values of an image are non-negative ($x \in R^+$). Convolution with a Gaussian filter guarantees a non-negative result, so such function maps non-negative values to other non-negative values ($f: R^+ \rightarrow R^+$). The result is therefore always another valid image.

C. Segmentation

Segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. It involves partitioning an image into groups of pixels which are homogeneous with respect to the pixel labeling criterion. Two segmentation approaches are employed in the present work namely color based segmentation using k-means clustering and thresholding based masking.

Color Based k-means Segmentation: Pre-processed image i.e., filtered image is input to the k-means clustering algorithm with *k* value being 2 and Squared Euclidean Distance Metric is used to quantify how close two objects are to each other. Here, the value of *k* is chosen based on the heuristic that green pixels in the image belong to healthy portion of the leaf sample and should be separated out from that of diseased portion. Thus, k-means clustering approach divides objects into two clusters.

The procedure is performed as follows:

Step 1: Read in filtered image

Step 2: Convert image from RGB Color Space to L*a*b* Color Space

The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis.

Step 3: Classify the colors in 'a*b*' space using K-means clustering with Squared Euclidean Distance Metric.
Step 4: Label every pixel in the image using the results from cluster indices returned by K-means.
Step 5: Create images that segment the input image by color based on pixel labeling.

Now, to make the process automated, the cluster containing region of interest i.e., diseased leaf spots, must be chosen without human intervention in the system being developed. To achieve this, continuous experimentation was performed programmatically in offline processing because k-means do not return the same cluster index value for an input image every time it is executed upon. For this reason the mean values of chromaticity layers a* and b* are calculated and this yield the final cluster center means for each cluster. From experimentation, it is observed that the cluster having the objects of Region of Interest (ROI) has the least cluster center mean. Based on this reasoning, the cluster having Region of Interest is chosen automatically during execution and thus making the system automatic during online processing. The result of this approach is shown in figure 2 and it can be observed that 'objects in cluster 1' is the required region of interest. But, this cluster contains the background of the image (in white color) along with diseased leaf spots extracted which must be separated out. Hence, the next approach i.e., thresholding is applied.

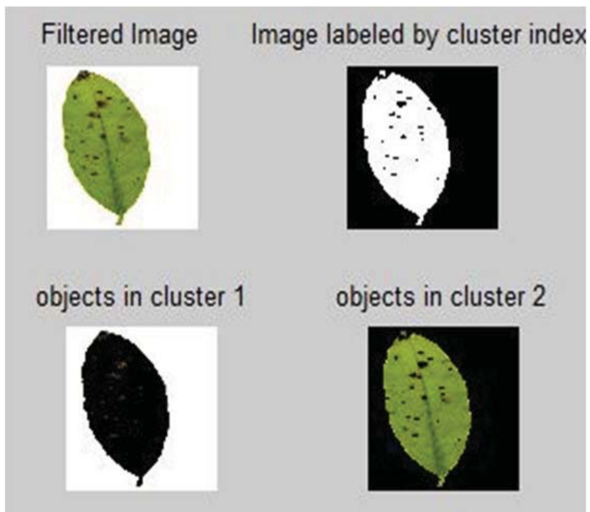

Figure 2. Color Based k-means Segmentation

Thresholding Method: This approach reads in the RGB input image resulted from k-means clustering approach i.e., the image with region of interest containing diseased leaf spots. The procedure begins with reading the pixel values of red, green and blue bands separately. Programmetical observation showed that diseased portions of the image are visually clear in green band and contain pixel values less than that of non-diseased portions. Hence, this value is chosen as threshold to attenuate the pixel with higher range in the image in green band. On this basis, a mask is created containing R, G, and B values of pixels representing diseased portion as 1 (one) and rest being 0 (zero). This mask is applied on the input ROI image to extract only the region of interest as shown in figure 3.

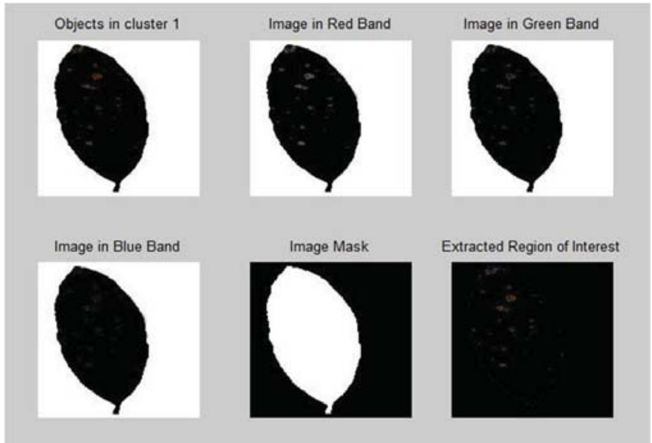

Figure 3. Extracted ROI using Thresholding Method

D. Feature Extraction

First-level Haar Wavelet Transform (HWT) is used to extract the features from the image obtained from thresholding method. Haar transform is derived from the Haar matrix whose elements are either -1, 0 or 1 multiplied by integer powers of sqrt(2) [8]. Haar transform can be expressed in the following matrix form:

$$T=HFH^T \qquad (1)$$

where F is an N X N image matrix, H is an N X N Haar transformation matrix, and T is the resulting N X N transform. For the Haar transform, H contains the Haar basis functions, $h_k(z)$. They are defined over the continuous, closed interval $z[0, 1]$ for $k=0, 1, 2, \ldots, N-1$, where $N = 2^n$.

Mean and standard deviation of coefficients resulted from four sub-bands namely, one approximated image and three detailing images from ROI image decomposition are calculated in the proposed approach and stored as a feature database. Four coefficients are obtained by applying discrete wavelet transform (dwt) while image decomposition and another four by applying inverse discrete wavelet transform (idwt) for image reconstruction. For each feature, its mean and standard deviation are recorded. This way, the feature database consists of 16 features for each image sample.

E. Disease Detection and Classification

Fuzzy Inference System (FIS) editor of MATLAB's Fuzzy Logic Toolbox™ is used for foliar disease detection and classification. Mamdani type fuzzy classifier is used with three input vectors and two output vectors. Each vector incorporate triangular membership functions fed with feature values in ranges obtained from feature extraction phase. 'Rulebase' contains six rules for appropriate classification all with equal weight of 1(one). Figure 4 shows Fuzzy System elements.

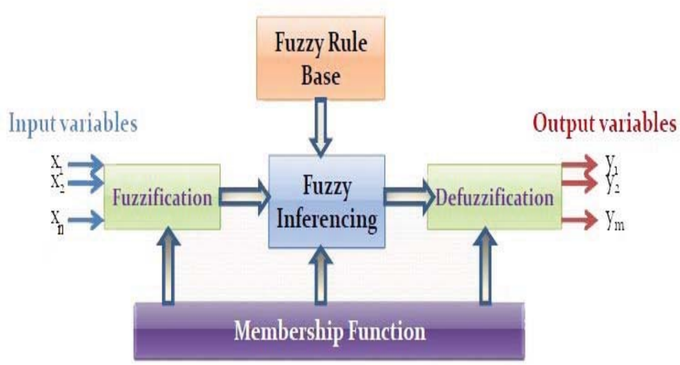

Figure 4. Fuzzy System Elements

F. Treatment Measures

The proposed treatment advisory is a simple information providing system that works on the basis of results obtained by the fuzzy classifier. It provides the information to the farmers/agronomists on what fungicides to be sprayed, quantity of the spray and spray intervals based on the type of the disease identified as shown in figure 5.

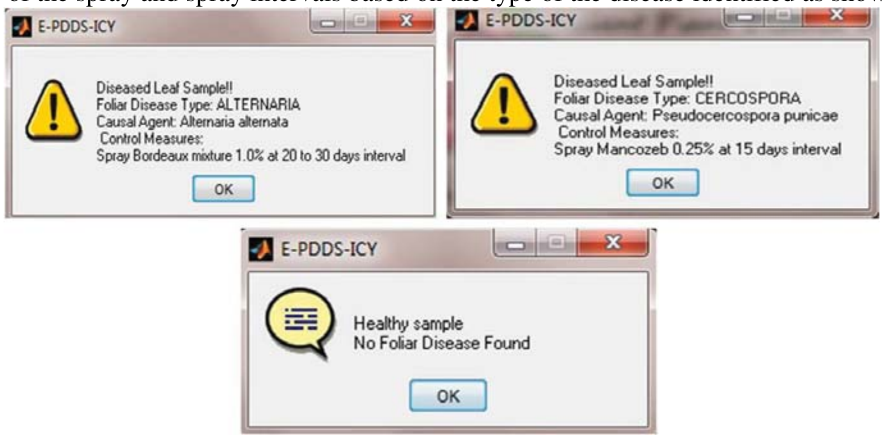

Figure 5. Treatment Measures

IV. CONCLUSION

The proposed plant disease diagnosis system serves the farming community to improve their crop productivity by correctly classifying the disease type being occurred. The system is developed to detect and classify the pomegranate plant foliar disease spots. The system effectively segments the diseased portion of the image of pomegranate leaf sample using color based segmentation using k-means clustering and thresholding based region extraction (diseased spots). The system accurately detects diseased spots present, if any and classifies the type of the disease being affected using fuzzy classifier based on the features extracted from the diseased portion using first-level Haar Wavelet Transform. Treatment measures are provided to farmers for respective disease type classified. The result obtained helps farmers/agronomists in making effective decisions early and efficiently to protect their crops from heavy loss due to a vast spreading of diseases.

V. FUTURE ENHANCEMENTS

The proposed system aims at classifying two foliar spot diseases of pomegranate crop affected by fungal microorganisms and provides treatment measures only for the diseases identified. The system focuses on two fungal diseases by causal agents, alternaria alternata and pseudocercospora punicae and may be developed further to identify diseases occurring by other fungal agents. This can further be extended to diagnose other diseases affected by different microorganisms such as virus and bacteria. The system may be established further to classify diseases of other crops and different parts of the plants may also be considered if a thorough research is carried out collaborating Information Technology and Precision Agriculture.

VI. ACKNOWLEDGEMENT

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