Computer based Diagnosis of Leaf Rust Disease using Multiclass SVM

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Abstract **– In recent days, agriculture degradation is caused by several aspects which include insufficient resources, diseases and natural defects. Leaf rust is a fungal disease caused by pathogenic fungi of the order Pucciniales, which reduces grain yield by more than 20 per cent in susceptible varieties and reduces grain quality. Leaf rust disease are transmitted through the air and soil. It causes major economic loss for farmers worldwide. This paper details an automated approach developed by the author, for Leaf rust diseases detection which is more accurate and efficient. The automated approach makes use of image processing techniques to enhance the quality of the image and to diagnose the disease. The process involves image acquisition, pre-processing, segmentation, analysis and classification of the disease. It is tested with five types of leaves such as Barley, Maize, Oats, Paddy and Wheat. From the experimental results, it is concluded that the proposed method with Multiclass support vector machine provides better accuracy. Finally, performance of the method is analyzed and it results in 99.5% accuracy when comparing with the traditional methods.**

Index Terms - Computer Based Diagnosis, Leaf rust, Image acquisition, Pre-processing, segmentation, Analysis, Classification, Image processing, Multiclass SVM.

I. INTRODUCTION

Leaf rust diseases have grown to be a dilemma as it can affect significant diminution in both quality and quantity of agricultural income yield. The economy and prosperity of a country depends on agriculture production. Agriculture provides food as well as raw material for industry. Agriculture production is inversely affected by rust infestation and diseases.

The Food and Agriculture Organization estimates that the pests and leaf rust diseases are responsible for 25% of crop loss. Early rust identification and detection will help to minimize the loss of production. The plant pathologists mostly rely on manual eye prediction techniques for detecting, recognizing and grading of diseases on plants [5]. This type of technique for grading is very time taking. Moreover, the expert advice is not reasonably priced and is not timely accessible to farmer. There are issues with the efficiency in manual grading system and results are not accurate [17] [31].

Computer vision technology is used for the detection, grading of the leaf disease and image enhancement for detection of Plant Leaves Disease [5]. It can conduct real-time diagnosis for diseases accurately, rapidly and effectively by analysing the common types and characteristics of diseases [15]. A typical image recognition process includes image pre-processing, segmentation, feature extraction and leaves recognition.

Image Pre-processing includes resizing, thresholding and filtering. Image segmentation directly influences the reliability of feature extraction and the accuracy of leaf recognition [12]. Segmentation algorithm for paddy leaf disease include threshold methods, edge detection, clustering methods and segmentation methods based on statistical pattern recognition or neural networks [7].

Currently, image segmentation techniques are used in Paddy [7], Maize leaves and multi-graph-based segmentation for wheat powdery mildew and stripe rust diseases [10]. The optimized spectral indication is derived from the image conversion method. In Wheat leaf, the most and least relevant wavelengths for different diseases are extracted from leaf spectral data [1]. Gaussian process regression represents better performances than other methods [1]. Gaussian process regression method is slow, less accurate and more expensive comparing with Multiclass Support Vector Machine. Thus Computer based approach using Multiclass SVM is developed to diagnose the Leaf rust disease with higher accuracy.

In this paper, an automated approach is developed to diagnose Leaf rust disease. The k-means clustering algorithm is used to automatically separate diseased region from non-diseased region of leaves. Using Multiclass Support Vector Machine, the type of rust is classified and the remedies are given accordingly, which helps to improve the quality and quantity of crops.

This paper is organized as follows. Section II, briefly summarizes the Related work. Section III, provides the description of the System overview. Section IV, describes the Proposed framework in detail. Section V, presents the Experimental results and analysis. Conclusions and future work are given in Section VI.

II. RELATED WORK

Diseases are mostly seen on the leaves of plant, precise quantification of these visually observed disease traits has not well studied yet because of the complexity of visual patterns [5]. The problem of detection of leaf rust diseases and the amount of diseases in them has long been an issue of concern in agriculture sector for crop quality and quantity management. Visual identification of diseases on leaves is labor demanding, less precise and can be done for small regions only. So, the automated detection of diseases in plants is an important research as it may provide advantages in

Supervising large fields of crops. Hence there has been increasing demand for more specific and sophisticated image pattern understanding techniques. Many researches have been carried out for developing numerous leaf disease detection systems using computer vision and image processing techniques. Some already developed systems are explained in this session.

Color conversion and histogram equalization is used to improve the quality and clarity of images. This is a primary step of plant leaves diseases detection [23]. Image enhancement contains sequence of techniques which are used to convert and improve the appearance of an image. Captured images have low quality and poor contrast. Therefore enhancement of image quality and clarity is important one in the plant leaves disease detection [15]. From the image enhancement process high quality, visibility and better contrast images are developed.

Grayscale images are easy to process in any application because they have only intensity values [7]. The histogram equalization enhances the contrast of images by transforming the intensity values.

Color co-occurrence methodology was used for extracting features, which uses both the color and texture of an image to draw unique features of the input image [29]. The ability of discrimination of the color histogram is largely dependent upon the selection of the method used for quantization of color.

In [7], *Suman T and Dhruvakumar T.* proposed a system for detection of diseases taking into reference with various diseases in Paddy leaves. Segmentation techniques are used to detect diseased portions in the plants. In this, the shape and features of the images are extracted. Self-Organize Map (SOM) neural network is utilized for classifying of the diseased Paddy leaves. The disadvantage of this technique is that when the image gets zoomed, the output is not accurate.

In [31], *Weizheng S.* proposed an image processing based method for grading the leaf spot disease in plant leaves. They performed an analysis on all the influencing factors that were present in the process of segmentation. Otsu Method was used to segment the leaf regions. In the HSI color system, H component was chosen for segmentation of the diseased spot. Further Sobel operator was taken into function in order to examine the edges of the disease spots. Finally, grading was done by estimating the quotient of the diseased region and leaf areas.

In [9], *A.Meunkaewjinda et al.* proposed a disease detection in grapes using hybrid intelligent system in which the diseases in leaves of plants are graded by calculating the quotient of diseased area and the leaf area. Self-organizing maps back propagation neural networks was used by them for recognizing the colors of the grape leaves that were used to segment he pixels of the grape leaf within the entire image. After that disease segmentation is performed. Gabor wavelet is then used to filter the segmented image in order to analyze the color features of the leaf. After that support vector machines are applied in order to classify the different types of diseases in grape leaves. In this method the Segmentation is good but there is limitation in extraction of ambiguous color pixels from the background of the image.

The vegetation indices from hyper spectral data have been shown for indirect monitoring of plant diseases. But they, cannot distinguish different diseases on crop. In [8], *Wenjiang Huang et al.* developed the new spectral indices for identifying the winter wheat disease. They consider three different pests (Powdery mildew, yellow rust and aphids) in winter wheat for their study. With the usage of back propagation neural network, there is an inability to know how to precisely and accurately generate an arbitrary mapping procedure.

The complex impacts of disease stages and disease symptoms on spectral characteristics of the plants lead to limitation in disease severity detection using the spectral vegetation indices (SVIs) [1]. Although machine learning techniques has been utilized for vegetation parameters estimation and disease detection, the effects of disease symptoms on their performances have been less considered.

The combinations of disease symptoms at each disease severity level resulted in very complex spectra which declined the accuracies of PRI and NBNDVI. However, they did not have adverse impacts on PLSR, ν-SVR, and GPR performances. The Gaussian process regression performance using smaller training dataset results in higher accuracy than other implemented methods. Additionally, challenges in early detection of plant disease due to minor change in reflectance could be reduced using machine learning regression techniques. It must be noted that PLSR, ν-SVR, and GPR need to be tested on various sensors and different varieties of wheat in order to be used in the field [1].

Spectral data at the leaf and canopy scales have been utilized to improve the plant diseases detection techniques from remotely sensed observations [1], where the visible and infrared regions are more sensitive to disease development [9]. The measured spectra can be utilized to early detection of fungus disease [1] and to forecast wheat powdery mildew disease [10]. Moreover, the optimized narrow bands vegetation indices were employed to discriminate various disease of wheat [8].

In [11], *Xu Pengyun et al.* proposed a technique for monitoring plant diseases that were caused by spores. The colored images is firstly converted in to gray scale image so in order to analyze the process through histogram generation, the gray-level correction, image feature extraction, image sharpening and so on. Moreover in order to remove the components of the image having low frequency, the edges of the grayscale image is enhancing using Median Filter and canny edge algorithm. After thresholding, morphological features like dilation, erosion, opening etc., are applied on the binary image obtained .The drawbacks for this technique is the processing time that appears to be high and there also exists variations in the size of spores.

In [17], authors have proposed detection and classification of grape leaf diseases using Neural Networks (NN). In this system, grape leaf image is taken as input. Thresholding is deployed to mask green pixels. An anisotropic diffusion is used to remove noise. Then by using K-means clustering grape leaf disease segmentation is done. Using Neural Networks the diseased part is recognized.

In [12], *Xiaojing Niu.* proposed a technique for detecting plant disease using image segmentation. The color images is firstly converted in to gray scale image, to analyze and process though histogram generation the gray-level correction, image feature extraction and image sharpening. Moreover in order to remove the components of the image having low frequency, the edges of the greyscale image is enhancing using Median Filter and segmentation is done for identifying whether the leaves is infected by the disease or not.

In [23], *Chaudhary P.* proposed the Color transform based approach to detect disease spot on plant leaf. In this paper a comparison of the effect different types of coor space in the process of disease spot detection given. All color models (CIELAB, HSI and YCbCr) are compared and the component CIELAB color model is used. Median filter is used for image smoothing. Finally by using Otsu method on color component, threshold can be calculated.

In [2], *Anand R.* proposed a method for identifying plant leaf disease and an approach for careful detection of diseases in brinjal. The goal of proposed work is to diagnose the disease of brinjal leaf using image processing and artificial neural techniques. The diseases on the brinjal are critical issue which makes the sharp decrease in the production of brinjal. The leaf spot disease is considered in this work and it is possible to identify the disease using k-means clustering algorithm and ANN. Various parameters are computed as Area, Perimeter, Centroid, Diameter and Mean Intensity for identifying a brinjal diseases.

In [31], *Weizheng S.* proposed a technique for grading of plant diseases, it mainly depends on eyeballing, a new method is developed based on computer image processing. All influencing factors that existed in the process of image segmentation was analysed and leaf region was segmented by using this method. In the HSI color system, H is a component chosen to segment disease spot to reduce the disturbance of illumination changes and the pattern.

Therefore, Computer based detection of leaf rust diseases is an important research topic as it may prove benefits in detecting diseases automatically from the symptoms that appear on the plant leaves in early stages. Multiclass Support Vector Machine (SVM) is used to diagnose the presence of rust in leaves.

III.SYSTEM OVERVIEW

This section presents the system overview of Leaf rust disease diagnosis in detail. The developed automated approach for the diagnosis of Leaf rust disease is shown in Figure 1.

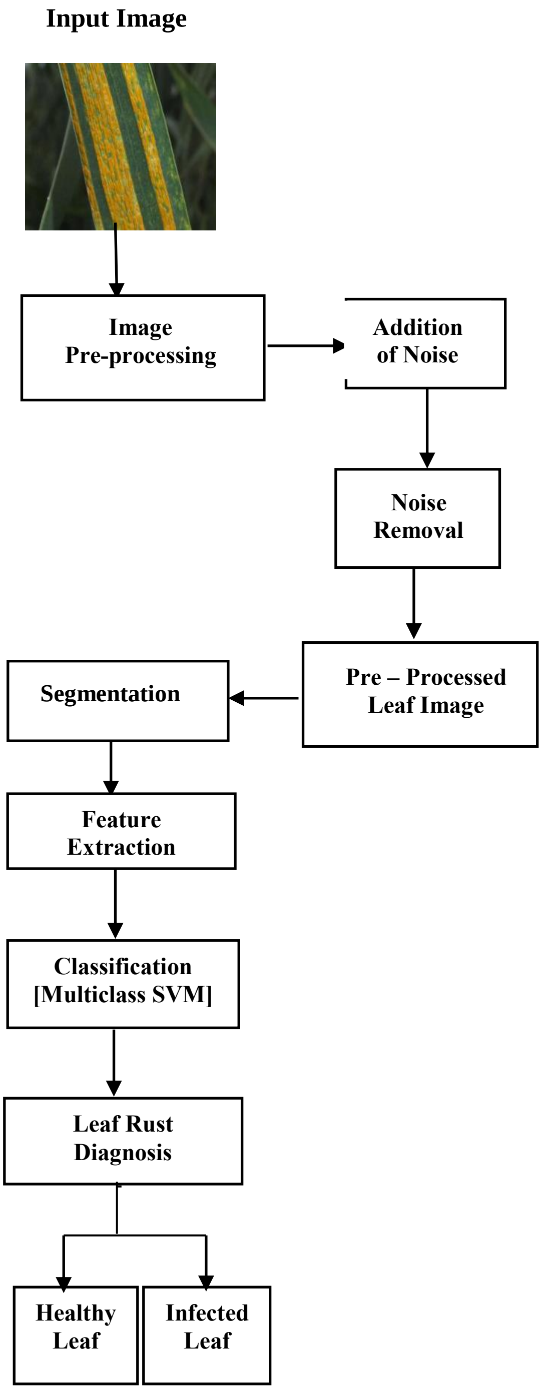


Figure 1. System Overview - Leaf Rust Diagnosis

The steps include Leaf image Pre-processing, Segmentation, followed by Feature extraction and Classification of the input leaf as normal and abnormal leaf with the presence and absence of Leaf rust. To improve the quality and quantity of Barley, Maize, Oats, Paddy and Wheat crops this Multiclass Support vector machine classification is used.

IV.THE PROPOSED FRAMEWORK

This section presents the implemented methods for leaf Segmentation, Feature computation and Classification. The system takes plenty leaves as the input and segments the leaf region of the input leaf using Multiclass SVM classification method. For the segmented leafs, the system extracts more features as input to a pre-trained classifier. Finally, the classifier outputs its confidence in classifying the input leaf as, effected by pathogens is positive case or negative case based on the computed features.

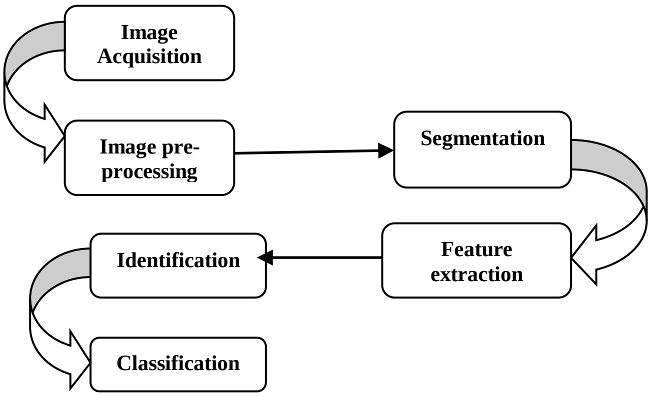


Figure 2. Image Processing Process

A. Image Acquisition

Image acquisition is the first step, the infected and healthy leaves of Barley, Maize, Oats, Paddy and Wheat are collected, which are required to train the system. Barley, Maize, Oats, Paddy and Wheat leaf images are also taken using digital camera and used for both training and testing the system [10]. The standard jpg and png format is used to store these images. In this study, images are collected from different types of regions. Few of the images have been taken from internet. Collected images include the leaves infected by brown rust, yellow rust, anthracnose, hollo spot and powdery mildew.

B. Image Pre-Processing

Image Pre-processing, resamples the input Leaf image by increasing the Grey scale contrast and to improve Leaf image quality. Image pre-processing step involves addition of noise, removal of noise to suppress unwanted distortions and enhance the feature of the image for further processing. In this phase, the captured images will be cropped and resized so that it can be effectively used for testing. The reason for the need of image pre-processing includes:

- Noise reduction
- Contrast enhancement
- Resize Image
- Filter Image

C. K-Means Segmentation Algorithm

In image segmentation, the infected and healthy leaves are segmented into homogenous regions with respect to certain features. Clustering is a method by which the large sets of data are grouped into clusters of smaller sets or segments of similar data. [2] K-means clustering is used to for segmenting an image into three groups. The clusters contain diseased part of leaves. Before clustering 'a' component is extracted from L*a*b space. K-means is used for grouping similar pixels of an infected and healthy leaves. It is a straightforward and fast approach. In k-means, k number of clusters is generated from the infected and healthy leaves. RGB space is converted into L*a*b space where L is Luminosity and a*b are the colour space. The reason for this conversion is the fact that while considering the leaf image, there is no necessity of dealing with luminosity factor. Each cluster has a variable cluster centre which starts from the initial values called seed-points.

D. Feature Extraction

Feature extraction of an image is a property in image processing where the major attributes which have to be analysed are extracted. For recognizing the plant to which the leaf belongs, 11 features have been extracted for 28 leaves of which 20 leaves have been considered for training the system and 8 leaves for testing the system. On the other hand, 4 features of the GLCM matrix (including contrast, energy, homogeneity, correlation) have been calculated for detecting the type of disease and for grading it. As a result, a feature file is being created which is being sent to the ANN toolbox for training to diminish the mean square error.

E. Classification

Multiclass Support Vector Machine is a supervised learning model used as Classification algorithm for Leaf rust diagnosis.

The Multiclass SVM tool box provides functionality for designing complex systems of nonlinear nature which cannot be modelled easily using a closed form equation. Once the feature file is created and output values of the images are decided, then the system can be trained using Multiclass SVM tool box. The command to start Multiclass SVM is "nnstart" in MATLAB which then opens the toolbox. Then the pattern recognition tool is selected for training the files to reduce the error. Multiclass SVM classifies the computed feature vectors into either normal or abnormal (infected or healthy leaf).

V. EXPERIMENTAL RESULTS AND ANALYSIS

This section presents the practical evaluation of the work. Segmentation and feature extraction is performed. The leaf image is taken as an input image and the diagnosis of Leaf rust disease is performed.

Leaf image pre-processing is an initial step in the process. Pre-processing of the leaf includes resizing and removal of the noise using filter. In Figure 3(a). The leaf image is taken as an input and the input image is shown.

Figure 3(a). Original Image

Median Filter is a filtering operation to remove the noise in the input leaf image and provides better accuracy. Median Filter is performed on input image to remove noise which is shown in Figure 3(b).

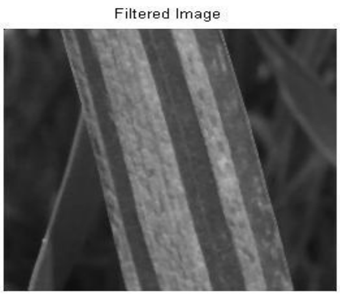


Figure 3(b). Filtered Image

HSV color space is used for assigning different colors to the foreground and background of the image in comparison to the equivalent RGB image. The functions rgb2hsv and hsv2rgb to convert images between RGB and HSV color spaces.

HSV color space consists of three components namely the Hue, the Saturation and the Value. The 'Hue' represents the color, the 'Saturation' represents the amount to which that respective color is mixed with white and the 'Value' represents the amount to which the respective color is mixed with black. In Figure 4(a). The HSV image is shown

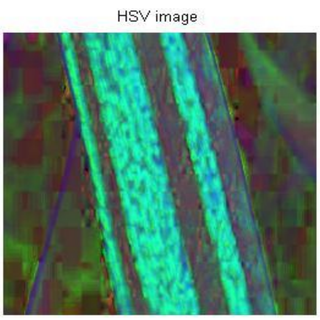
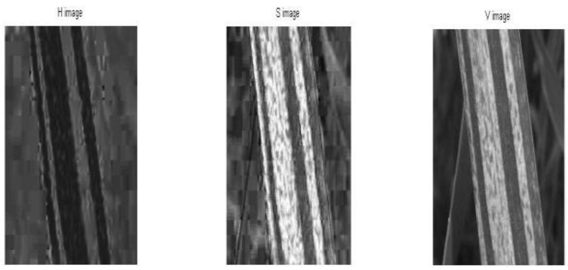


Figure 4(a). HSV Image

As hue varies from 0 to 1.0, the corresponding colors vary from red, through yellow, green, cyan, blue, and magenta, back to red, so that there are actually red values both at 0 and 1.0. As saturation varies from 0 to 1.0, the corresponding colors (hues) vary from unsaturated (shades of gray) to fully saturated (no white component). As value, or brightness, varies from 0 to 1.0, the corresponding colors become increasingly brighter. In Figure 4 (b), (c), (d). The Hue, the Saturation and the Valve image is shown.



(b). Hue Image (c). Saturation Image (d). Value Image

Then the image is segmented into three clusters using K-means clustering. The texture and color features of all three segmented images are extracted. The nine texture features and nine color features are calculated for all three segmented parts of single leaf image. In Figure 5. The three clusters formed using K-means clustering is shown.

Figure 5. Segmentation using K-means Clustering

Classification is performed using Multiclass Support Vector Machine to diagnose the presence and absence (infected and healthy leaf) of rust in leaves. Using Multiclass Support Vector Machine classification the defective parts are detected and maximum disease affected areas identified, shown in Figure 6(a) and (b).

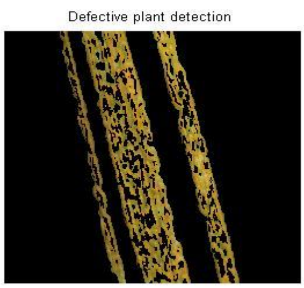


Figure 6(a). Defective part detection

Figure 6(b). Maximum disease affected areas

Multiclass Support Vector Machine also classifies the type of leaves which include Barley, Maize, Oats, Paddy and Wheat. It also helps to analyse and provide remedies based on the classified stages of Leaf rust disease.

VI.CONCLUSION

The automated approach is developed to diagnose Leaf rust disease based on Multiclass SVM Classification. Based on the test conducted, it is observed that the automated approach provides better performance.

The Leaf rust disease are identified using image processing techniques which include resizing, thresholding and HSV filtering. K-means clustering technique is used for segmentation and the feature extraction is done using texture and color features. Then the Multiclass SVM classification technique is used to detect the type of rust and its remedies, which helps to improve the quality and quantity of crops. Thereby, the defects caused by Leaf rust disease can be minimized.

In the Future work, many different leaves are tested to provide better efficiency. The performance of the system are analysed by using different classifiers.

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