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# Signal processing techniques for identification of plant diseases

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ABSTRACT

Plant pathology is a vast science with far reaching impact on human civilization. Self-sufficiency in food production is important for overall prosperity of any Modern Economy. Currently with the advance in overall Agricultural/Horticultural sciences, our overall Food production has been good. However, we neglect the often important factor of disease out-breaks which have economically affected the farmers at different instances. Sometimes, few diseases or symptoms are well known to farmers and could be easily diagnosed and in other cases, expert opinion is required, which is often not easily available. With the advent of cloud computing, penetration of mobile phones and availability of high-speed network, it is very easy to implement soft system, which could help our farmers identify different diseases based on image data captured by their mobile phone. To demonstrate the concept in this paper Alternaria Alternata, Anthracnose, Powdery Mildew in different species like Grape, tomato and Jute is considered. We discuss and implement feature extraction module to objectively construct a disease signature/ unique marker that could be used for specific disease identification across species irrespective of Plant type. In line with this strategy, a software architecture for Tele-pathology in plants is structured such that different diseases could be categorized. In a very short period of time, expert knowledge in the field of Plant Pathology could be objectified into easily usable tools and this would complement the already existing classical extension activities.

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## INTRODUCTION

India is a cultivated country and about 70 per cent of the population depends on agriculture. Farmers have large range of diversity for selecting various suitable crops and finding the suitable pesticides for plant. Disease in plant leads to the significant reduction in both the quality and quantity of agricultural products. The studies of plant disease refer to the studies of visually observable patterns on the plants. Monitoring of health and disease on plant plays an important role in successful cultivation of crops in the farm. In early days, the monitoring and analysis of plant diseases was done manually by the experts in that field. This requires tremendous amount of work and also requires excessive processing time. The image processing techniques can be used in the plant disease detection. In most of the cases disease symptoms are seen on the leaves, stem and fruit. This paper gives the introduction to image processing technique used for plant disease detection.

Alternaria Alternata, Anthracnose, Bacterial Blight, Cercospora Leaf spot, Powdery mildew, Black band (*Botryodiplodia theobromae*), Die back (*Glomerella cingulata*), Stem rot (*Macrophomina phaseolina*) and Soft rot (*Sclerotium rolfsii*) these are some of the illness that disturbs an extensive range of plants worldwide. Differentiating factors based on image analysis of diseased plants plagued by these diseases are highlighted and suggested to be used as a feature set for Machine learning classifiers. As an example case Jute is explained in this paper. A general strategy which fits all the classes above has been outlined.

In general, the strategy is to collect image dataset from different diseased plants species like effected leaf images, Stem segments, effected fruits etc. Like wise an image data set of healthy Objects is constructed.

Exemplary images shown in Fig. A, B and C is just a demonstration. A rich data set of such images is established. The idea behind images based disease identification is that a unique marker or signature is extracted from image of an affected area and akin to modern facial recognition techniques a set of features are extracted. An analogous explanation could be segregation of people of Asian vs European descent. This simple differentiation could be done by taking into account factors like skin colour, height, size of nose etc. If a person is tasked to do such a classification for a group of people constituting Asians and Europeans, he would look for such specific character as said above to associate a person to a specific race. Likewise, when a

(a) Healthy tomato leaf (b) Affected by Alternaria alternata

**Fig. A: Tomato (case: Alternaria Alternata )**

(a) Healthy grape leaf (b) Affected by powdery mildew

**Fig. B: Grape Leaf (case: Powdery mildew)**

(a) Healthy Jute Stem (b) Affected by Anthracnose

**Fig. C: Jute (case: Anthracnose)**

disease plant image is posed we construct a mechanism whereby a similar identification could be made and identification and association to a specific disease could be is accomplished.

Such system involve two part process as the major building block. Firstly, a set of mathematically defined and extractable features is derived. Once such feature set is available then Artificial intelligence comes into picture. The feature set for different set of values would correspond to different images, which in turn correspond to disease or a healthy plant. The feature is independent of image but it does contains the essence of that image in the sense that it would be indicative of whether the plant was healthy or was affected any particular disease. In the next section we would analyse Jute for different disease like Anthracnose. A similar analysis could be done for other diseases and for different species of plants.

## MATERIAL AND METHODS

In this section we formulate a set of feature and explain how the feature are extracted from a mathematical point of view. These feature when seen in correspondence with a specific disease for a plant species, represent an identification vector, which would be used for image association.

**Feature extraction:**

The significant features are extracted in order to perform the analysis via the color co-occurrence methodology which is derived from the GLCM (Grey-level co-occurrence matrices). GLCM is used for sampling an image statistically in a way certain grey-levels occur in relation to other grey-levels (Arivazhagan *et al.*, 2013 and Al-Hiary *et al.*, 2011). It also provides feature information about the position of the pixels of the image in relation to their neighboring pixels. For this research, thirteen (Singh and Singh, 2019; Phadikar and Sil, 2008; Zulkifli Bin Husin *et al.*, 2012 and Jhuria *et al.*, 2013) feature values have been reckoned for each of the training images and the input image to perform texture analysis. The features are mentioned below:

- Contrast
- Correlation
- Energy
- Homogeneity
- Mean
- Standard deviation
- Entropy
- RMS (root mean square) contrast
- Variance
- Smoothness
- Kurtosis
- Skewness
- IDM (Image difference-measure)

The above features are calculated from the GLCM using their corresponding formulas.

**Over all architecture:**

In line with the explanation in the introduction we introduced the concept of feature extraction first but in the system model feature extraction is a stage which arrives a little later after some initiate steps. The system model below Fig. D, describes the process flow of our proposed methodology.

The image captured by the farmer is loaded on to the processing module which could hosted on any cloud location or a system server or in case of a lab on a computer where the image would go through several levels of analysis.

The stages from segmenting the image to identifying the disease Anthracnose are described as followed. Note that this model is not disease or plant dependent but for the ease of explanation and scarcity of space only one species is discussed here.

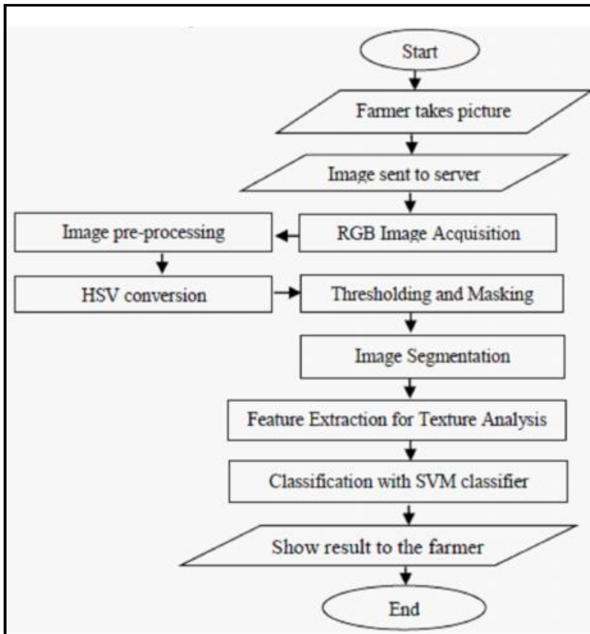


**Fig. D: System model**

**Image preprocessing:**

Before proceeding towards image analysis the image should be processed. Generally images taken from different sets of hardware contain different factors which alters the result of the analysis. The image preprocessing procedure is performed by following certain steps consists of image resizing, image enhancement and noise removal.

*Resize image:*

To perform the classification, the size of the input image must match the size of the images stored in the database. Thus, the input image must be resized to a fixed dimension at the very first stage**.**

*Enhance image:*

In this step the image intensity values or colormap is enhanced by adjusting the contrast of the image by defining the upper and lower limits of the pixel values that are used for stretching the image. The limits specified consider the bottom 1 per cent and the top 1 per cent of all pixel values of the image (http://www.mathworks.com).


**Fig. E: A jute stem infected by anthracnose**

*Noise removal:*

Images may contain noise. Nosie can alter the features of an image and leads to unexpected and deceptive result. Thus it is very important to remove the noise from the image. A modified Kalman smoothing filter has been used for noise removal. Using Kalman based method ensures that over smoothening is prevented and necessary image cues, which are indicative of disease, are not smoothened over (Jian *et al.*, 2016).

## Hue-based segmentation:

Hue-based segmentation method segments only the affected portion from the image. As the entire process has been conducted on stem disease, it is not possible to simply mask the green pixels from the image. Therefore, the hue-based segmentation method has been applied along with a customized thresholding formula.

*HSV conversion:*

At first, the RGB spaced image has been converted to HSV color space. In HSV, hue image conveniently represents the original color whereas saturation works well to mask the image and extract the region of interest (Gonzalez *et al.*, 2007). Then the individual channels have been extracted to separate the hue, saturation and intensity images.


**Fig. F: a) Hue, b) Saturation and c) Intensity image**

*Thresholding:*

Image thresholding is an effective way of dividing an image into a foreground and background. A threshold formula has been introduced to mask only the disease affected part of the stem from the image. At first, the saturation image is manipulated, where a binary mask is generated by thresholding the saturation image with a threshold value which is equal to ten percent of the maximum value of the image (Gonzalez *et al.*, 2007). Any pixel value greater than the threshold value is set to 1 (white) and all others are set to 0 (black) (Gonzalez *et al.*, 2007). After that the masked saturation image has been multiplied with the hue image. At this point the region of the stem from the image gets be separated. To extract only the disease affected portion of the stem and discard the rest the product image is masked again with a threshold value of 0.5 as the pixels with value greater than 0.5 prominently identify the disease affected region. Therefore, the comprehensive formula for thresholding appears as followed.

**Masked Image = M > 0.5**

where M = Hue * (Saturation >(Max(Saturation) * 10%))

**Fig. G: Masked image**

*Blob detection:*

The masked image still contains some unwanted regions. In order to remove them, morphological analysis is performed which includes erosion and dilation and the largest connected component is extracted using eight-way local neighborhood measurement.

**Fig. H: Segmented blob**

*RGB conversion:*

For further analysis, the segmented portion needs to get back to its original colour by being converted to RGB color space.

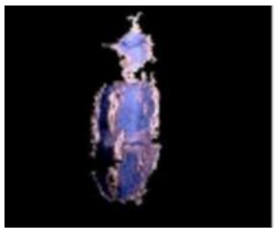

**Fig. I: Segmented RGB image**

**Feature extraction:**

As explained in the starting

**Classification:**

After the extraction, the necessary features are compared with the pre-calculated dataset. The SVM (Support Vector Machine) classifier is used for classifying the disease. Support vector machines (SVMs) are a set of related supervised learning methods used for classification and regression (Arivazhagan *et al.*, 2013). Supervised learning refers to the process where a given set of labeled observations are stored in the database and an unknown sample is analyzed and compared to assign it with a label according to the association with the labeled observations. SVM methodology basically takes the set of features, abstracts them and then positions a feature set on an N-dimensional Hyperplane.

For current analysis we show the analysis of a set of diseases affecting Jute. A set of five afflictions are evaluated here. Accordingly a multi-class SVM classifier is defined. The classification of new instances or input images is performed where the classifier with the highest output function assigns a class and detects the particular disease.

**Create database and train classifier:**

As discussed above that an SVM engine positions a feature vector on an N-dimensional hyperplane, training an SVM module is the process of identifying the position of that hyperplane. The labelled data, when processed through an SVN engine would generate support vector. And accordingly when a test feature set is presented it gets positioned on one or the other side of that Hyper plane. The training data set contains 200 specimens and each of these 200 specimen have a feature set of 13 features and are labeled. Once the SVM module is trained, it understands the variability and statistics of the 13 features according to their label. When test images are presented *i.e.* when test image feature set is present the SVM module easily identifies to which class does a feature set belong and consequently disease gets identified.

## RESULTS AND DISCUSSION

For our research, we examined different species with different disease affliction. One important aspect which stands out during the course of the work was that segmented and unsegmented image analysis gave different results. This underlined the fact that part of the plant analyzed played a role. The current analysis restricts explanation to Jute and a set of five diseases as expressed by the plot demonstrates the accuracy levels achieved by our approach Fig. 1.

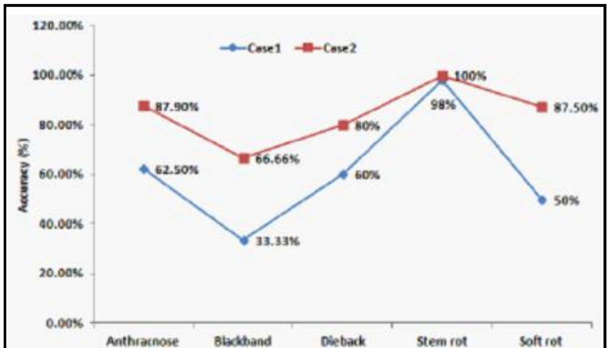


**Fig. 1 : Result, case 1 - unsegmented and case 2 - segmented**

From the observation of both cases, we found that case 1 provides us with 60 per cent of accuracies in detecting the diseases whereas case 2 provides an accuracy of around 86 per cent which is far better than case 1. A comparison diagram between two cases based on detecting five diseases is shown in Fig. 2. Over all, case I provides an accuracy level of 60% whereas case 2 performs with an accuracy of 86%.

and …In both cases the following formula is used

**Total percentage of accuracy = (C x 100) / N**

where, C = Number of correct outcome

N = Number of test image

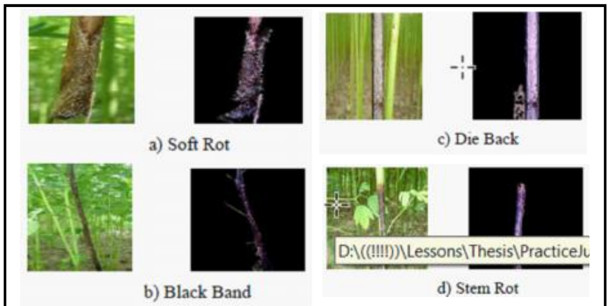


**Fig. 2 : The original images of a) soft rot, b) black band, c) die back and d) stem rot along with their segmented image**

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