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Plant Leaf Disease Detection Using Different Methodologies – A Survey

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Abstract

The economy of India is driven mainly by our agriculture. In this sense, the identification of diseases of the plants is very important to avoid losses in the yield and the quantity of the agricultural product. Studies of plant diseases mean the studies of visually observable patterns seen in the plant, especially on the leaf. The monitoring of health and the detection of diseases in plants is very critical for sustainable agriculture. Monitoring plant diseases manually is very difficult. It requires a huge amount of work, experience for plant disease detection and requires an excessive processing time. Therefore, image processing is used for the detection of plant diseases. The detection of plant leaf diseases involves the key steps of image processing such as image acquisition, image pre-processing, image segmentation, feature extraction and classification. This paper discusses the different methods used for the detection of plant diseases using their leaf images.

Keywords: Plant leaf disease; Image acquisition; Segmentation; feature extraction.

1. Introduction

The backbone of the economy in most developing countries, especially in India, is agriculture. The quantity and quality of crop production depends on the growth of the plant. India is a cultivated country where 7 out of 10 people depend on agriculture. Farmers have a wide range of diversity to select several suitable crops and find the right pesticides for the plant. Climate and other environmental conditions cannot be controlled by farmers. The mitigation of the disease is the main factor to consider in the case of agricultural practices to make it sustainable. Immediate attention should be given to crops that are affected by pests or diseases. If an adequate control on the leaves is made during the initial stage then, a greater propagation of the disease in the plants can be avoided. Observation with the naked eye makes it difficult to recognize the disease in the leaf. This can result in incorrect application of pesticides and, ultimately, results in crop failures, resulting in huge monetary losses for our farmers, many of whom borrow large loans for agriculture. Due to several factors in the environment, there are many diseases that are affecting crops. This leads to reduction in the quality and productivity of the plants. The disease in the plant leads to a significant reduction in both the quality and quantity of agricultural products. The study of plant disease refers to the study of visually observable patterns in plants, especially their leaves. Therefore, the detection of leaf disease of the plant is very essential in the initial stage and taking the necessary steps at the beginning can prevent it from spreading to other parts of the field. Normally, the farmer identifies the disease by observing the color and shape of the leaves. This method requires huge experience and many regular efforts, so it is practically impossible for large fields. The monitoring of health and disease in the plant plays an important role in the successful cultivation of crops on the farm. In the olden days, the monitoring and analysis of plant diseases was carried out by the expert in that field. This requires a huge amount of work and requires an excessive processing time. In most cases disease symptoms are spotted on the leaves, stem and fruit. Considering some case studies, the disease in the sugarcane plant, for example, is not only reducing yield but also the deterioration of the variety. The quality of sugarcane production depends on its robustness of the disease. With about 15% of sugarcane spots disease infection on leaves, sugarcane production has significant severe loss [1]. To control these diseases and minimize the infection of the entire sugarcane plantation, the disease must be identified and treated before. There are three major spot disease types, namely rust spot, yellow spot, and ring spot, which infect the tropical yield. The symptom of these fungi-caused diseases appears on a leaf as unique spots. These spots can be manually recognized based on the spot characteristics [2]. Cotton, "The White Gold" or the "King of Fibers" it enjoys a pre-eminent status among all cash crops in the country and is the main raw material for the flourishing textile industry. That provides livelihoods to nearly sixty million people and is an important agricultural product that provides remunerative income to millions of farmers in both developed and developing countries. The diseases identified on the cotton leaf spots are classified as Fusarium wilt, Verticillium wilt, Root rot, Boll rot, Grey mildew, Circular dry brown, Leaf blight, Bacterial blight, Leaf curl [3]. Similarly, in India, the productivity of the grape

is higher worldwide and there is still the possibility of increasing it. The export of grapes from India is approximately 54,000 tons valued at 48,000 (1000US $) which makes a portion of almost 1.45% of the total export of grapes in the world. Almost 70% of the population depends on agriculture. Grapes are an important fruit in India. Due to the disease in the grape plant, there is a loss of around 10-20% of the grapes [4]. Therefore, we must identify the diseases in the initial phase and suggest solutions to the farmers so that damage to the crop can be avoided and productivity increased. Generally, the basic steps for plant disease detection using image processing are shown in Fig. 1.

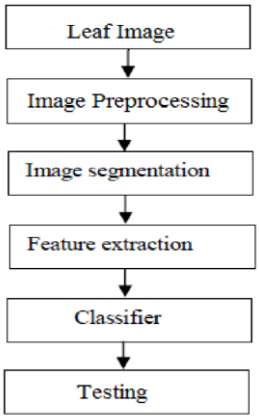

Figure 1. Steps for plant disease detection using image processing

Image Acquisition. The images of the leaf of the plant are captured through the camera. This is usually done manually to generate an accurate data set. The captured leaf image is in RGB (Red, Green and Blue) form. Corresponding to the RGB leaf image a color transformation structure is created, and then, a device-independent colour space transformation for the colour transformation structure is applied. In the image acquisition process, healthy and unhealthy leaves are processed initially. These unhealthy and healthy data sets are called the training data set [5].

Image Pre-Processing. The improvement of the image is the way towards the modification of advanced images so that the results are more appropriate for a posterior examination of the image. The main motto of image processing is to improve, soften and eliminate the noise that occurs during the capture of the image. To eliminate noise in the image or other object removal, different preprocessing techniques are considered [6,7]. Image clipping i.e. crop the portion of the leaf image to get the image region of interest. Image smoothing is done using the smoothing filter. Image enhancement is carried out for increasing the contrast.

Image Segmentation. Segmentation means partitioning of an image into several parts of the same characteristics or having some similarity. Segmentation process can be achieved using various methods like Otsu' method, k-means clustering, converting RGB image into HIS model etc. The Kmeans clustering method is used to classify objects based on several attributes into K number of Groups or clusters. The classification is performed to minimize the sum of square of distances in between the objects and the corresponding cluster [8]. In Otsu threshold algorithm thresholding creates binary images from grey-level images by setting all pixels below some threshold to zero and all pixels above that threshold to one [9].

Feature Extraction. The extraction of characteristics plays an important role for the identification of an object. In many image processing applications, concept of feature extraction is used. Color, texture, morphology, edges etc. are the features which can be used in plant disease detection. Feature extraction process [10] reduces the image data by measuring features such as color, size, shape, texture etc.

Classifier. These extracted characteristics are fed to a classifier, which classifies the leaves according to the type and magnitude of the disease.

Testing. Then, in the testing phase, the process of detecting leaf disease is carried out where it identifies the disease and gives the expert's suggestion to overcome the disease.

2. Literature Review

In [3] many advanced techniques of image processing used for detection of cotton leaf spot diseases is specified. The goal is to develop an advance computing system that can accurately identify the disease affected part of a cotton leaf spot by using the image analysis technique. Prediction of the diseases and pest recommendation is done in three languages like Tamil, English and Hindi. An exhaustive list of methods like neural network, back propagation and other pattern recognition concepts has been given in [19]. Although the responses of traditional methods are accurate, but it is still not up to the extent which can be considered for real life agriculture diseases. Therefore, some nature inspired technique can be used for increasing the efficiency of the results. A model to identify various sugarcane leaf diseases along with its severity estimation

and classification has been proposed in [2]. The proposed model of this research shows weakness from certain data which could not separate spot disease from the entire leaf along with the limitation of the segmentation method. Pre-processing of the leaf images can be applied so that the disease lesions on the leaf can be detected more accurately and therefore the disease can be identified more accurately. Also, more accurate segmentation method can be used, so that all spot areas can be separated accurately from the entire leaf image. Another research work [20] presented various techniques to segment the disease part of the plant. Using this method, the various plant diseases can be accurately identified at the early initial stage, thereby providing enough time to take necessary measures. The effective use of ANN methods for classification of plant leaf diseases such as self-organizing feature map, back propagation algorithm, SVMs etc. can lead to a better diagnosis of the disease. Another work [18] presented Groundnut Leaf Disease Detection and Classification by using Back Probagation Algorithm. Very less computational efforts are required in this technique for finding the plant leaf diseases that too at the initial stage. Similarly, Artificial Neural Network, Bayes classifier, Fuzzy Logic and hybrid algorithm scan also be used to increase recognition rate in classification process. Another technique which using the 1AA approach of multiclass SVM to classify and analyse many cucumber leaf diseases like leaf spot disease, leaf miner and CMV has been proposed in [21]. After pre-processing the cucumber leaf images, the cluster containing the diseased part of the leaf is chosen using *k*-means clustering algorithm. Early detection of the leaf disease is made possible by inspecting these images regularly, thereby preventing the spread of disease in large scale. In [22] authors presented the Support Vector Machine based regression technique for detection of five cotton leaf disease by developing an android app for displaying the disease and sensor information along with the ON/OFF of the relay. The app can also handle the movement of the whole system from one place to another. The use of Raspberry pi makes this system cost effective and independent. The comparison of all discussed methods is summarised in Table 1.

Table 1. A comparative analysis of various leaf disease detection methods

Publication	Methodology	Merits	Demerits	Potential Application Area	Datasets Used
IEEE, 2007.	Recurrent Neural Networks [17]	Uses very less computation time and can handle difficult and complex tasks	This nondeterministic training outcome is fully dependent on how one chooses the initial parameters	Detecting Leaf disease, recognizing standard speech	Plant leaf images taken manually
ITJ, 2011.	K-means clustering techniques [13]	Provides a guarantee that the number of false edges can be converged and reduced	The value K along with the initial set of clusters determines the quality of the solution	This technique finds its use in image segmentation.	Plant leaf images taken manually
IJCSIT, 2011.	Decision Tree classifier (DTC) [16]	Screening of variables, feature selection can be indirectly performed by Decision trees. Effort needed for data preparation is significantly less. Simple to interpret and explain	Achieving a globally optimal decision tree cannot be guaranteed due to instability, over fitting, unstable in small variations	Plant leaf disease classification and prediction, risk analysis	Plant leaf images taken manually
IEEE, 2012.	Homogeneous Pixel Counting technique for Cotton Diseases Detection (HPCCDD)[3].	Higher accuracy than other algorithms like SOM+BPNN, BP Neural Network etc.	Less optimal with data scarcity	Accurately detecting Cotton Leaf Spot Diseases.	Plant leaf images taken manually
IEEE, 2012.	Hybrid method of Noise reduction [11]	Helps to eliminate multiple Gaussian and speckle noise	Choosing the appropriate threshold value is difficult in performing wavelet analysis	Leaf disease detection	Plant leaf images taken manually

IEEE, 2013	K Nearest Neighbor (KNN) for classification [14]	Zero cost of the learning process all well as zero assumptions about the characteristics	Interpreting the model is impossible as there is no description of the learned concepts. Also finding the k nearest neighbors becomes computationally expensive especially when the dataset is very large.	Remote sensing, image classification for plant leaf disease detection and computer vision	Plant leaf images taken manually
IEEE, 2014.	Support Vector Machine classifier [2].	Can identify sugarcane leaf disease with high accuracy and low error severity estimation average.	Separation of spot disease from the entire leaf becomes problematic with certain datasets due to limitation of the segmentation process.	Human face and speech along with leaf image detection and recognition, categorizing text	Plant leaf images taken manually
IEEE, 2015.	Back Propagation Algorithm [18]	Efficient, accurate and automatic detection and classification of plant leaf diseases with complex background.	Analyzed only four leaf diseases	Leaf disease detection	Plant leaf images taken manually
Elsevier, 2017.	Genetic algorithm for segmentation [12]	Very less computational efforts and the optimum results	The population of chromosomes which are generated at the beginning determine the efficiency and time of the process	The efficient optimization of continuous or discrete variable is made possible using Genetic algorithms.	Plant leaf images taken manually

3. Discussion and Future Scope

Different plant leaf disease detection methodologies using different image processing and neural networks techniques are reported in the literature review section. Notable considerations are very highly cultivated crops like sugarcane and cotton. In a country which is dependent on agriculture it is vital to have productive cultivation. In this regard early and timely detection of plant leaf diseases will lead to improved production rate for the farmers. As scope for future work, these Plant Leaf disease detection techniques can be scaled to large farms. Also, the existing manual method of capturing plant leaf images can be replaced by using automated high-definition still and video cameras like drone cameras, to capture and analyze spot diseases on the leaf in real time thus saving precious time.

4. Conclusion

The different plant leaf disease detection methodologies using image processing, neural networks and data mining techniques are compared & described in this paper. The merits, demerits and potential application areas of each methodology are also detailed. Indian agriculture is plagued by many problems with failed crops due to plant diseases being one of the topmost contenders. These important points help the research experts and the policy making people in making the right decisions while analyzing plant diseases, especially those that can be visually identified from the plant leaf, thus ensuring a robust harvest for the most important contributors to our country's economy – our farmers.

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