Leaf Disease Detection, Quantification and Classification Using Digital Image Processing

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Abstract

Agriculture has become much more than simply a means to feed the fast-growing populations. Plants have become an important source of energy, and are a fundamental piece in the puzzle to solve the problem of global warming. There are several diseases that affect plants with the potential to cause devastating economic, social and ecological losses. In this context, diagnosing diseases in an accurate and timely way is of the utmost importance. This paper presents a study done on the use digital image processing techniques to detect, quantify and classify plant diseases from digital images. Although disease symptoms can manifest in any part of the plant, only methods that explore visible symptoms in leaves are considered. This was done for two main reasons: to limit the length of the project and because methods dealing with stems, roots, seeds and fruits have some peculiarities that would warrant a specific survey. The selected proposals throw light into three classes according to their objective: detection, severity quantification, and classification. Each of those classes, in turn, varies according to the main technical solution used in the algorithm. This paper is expected to provide a comprehensive and accessible overview of the various methods used for leaf disease detection, quantification and classification.

Keywords: *Digital Image Processing, Image Acquisition, Image Pre-processing, Image Segmentation, Feature Extraction, Classification, Disease Diagnosis.*

1. Introduction

India is an agricultural country and about seventy percent of the population depends on agriculture. Farmers have a wide range of diversity to select suitable fruit and vegetable crops.

However, the cultivation of these crops for optimum yield and quality product is highly technical. It can be improved with the aid of a technological support. Disease identification is a tedious task and most diseases are seen on the leaves or stems of the plant.

Diseases are important factors to restrict the growth of crops in agriculture producing, which may reduce yields of crops greatly and quality of products. At present, the diagnosis of crops diseases mostly depends on manual recognition, but some problems occur: on the one hand, it can be mistakenly diagnosed by farmers because they usually judge the symptom by their experiences; on the other hand, the disease treatment may be dallied over because the technician or expert can't go to locale to diagnose in good time. Relative to the person's vision, computer image processing technique take on some characteristics such as speediness, huge information and distinguish small diversity which can't be distinguished by person's eyes, so image processing technique can help farmers to judge the reasons and severity of crop diseases, and it takes on important theoretical and practical significance for improving the automatic management of crop. The research on crop disease recognition with image processing technology started latterly, which is mainly concentrated in the 80s to 90s years of 20th century and the beginning of 21st century. [1]

There are many types of plant Leaf Spot Diseases:

- Fungal
- Bacterial
- Viral

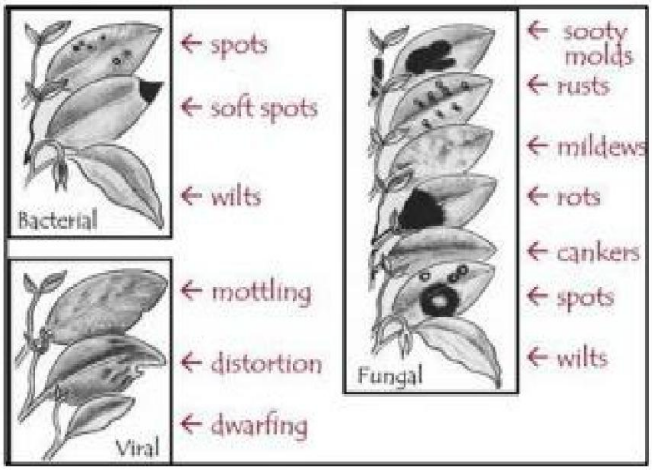

Figure 1: Various types of leaf disease

Most leaf diseases are caused by viruses, fungi and bacteria. Viruses are extremely tiny particles consisting of protein and genetic material with no associated protein. Fungi are identified primarily from their morphology, with emphasis placed on their reproductive structures and Bacteria are considered more primitive than fungi and generally have simpler life cycles with the difference that bacteria exist as single cells and increase in numbers by dividing into two cells during a process called binary fission. [2]

The image processing has become the key technique for the diagnosis of various features of the crop, providing a new approach to explore the field of agriculture. The image processing can be used in the agricultural applications [3,4] for the following purposes:

1. To detect diseased leaf, stem, fruit

2. To quantify affected area by disease.

3. To find the boundaries of the affected area.

4. To determine the color of the affected area

5. To determine size & shape of fruits.

6. To identify the Object correctly.

Many researchers have proposed image-processing and pattern recognition techniques in agricultural applications for detection of weeds in a field, sorting of fruits and vegetables, detecting diseases etc. Automatic detection of plant diseases is an essential research topic as it may prove benefits [5] in monitoring large fields of crops, and detect the symptoms of diseases as soon as they appear on plant leaves.

Figure 2: Affected leaves with- (a) Anthracnose disease, (b) Bacterial Blight disease

2. LITERATURE SURVEY

The literature survey describes the various papers suggesting to the diagnosis of leaf diseases using various approach suggesting the various implementation ways as illustrated and discussed below:

J. G. A. Barbedo(2013) presented a survey on methods that use digital image processing techniques to detect, quantify and classify plant diseases from digital images in the visible spectrum. Although disease symptoms can manifest in any part of the plant, only methods that explore visible symptoms in leaves and stems were considered. This was done for two main

reasons: to limit the length of the survey and because methods dealing with roots, seeds and fruits have some peculiarities that would warrant a specific survey. The selected proposals are divided into three classes according to their objective: detection, severity quantification, and classification. Each of those classes, in turn, was subdivided according to the main technical solution used in the algorithm. This survey is expected to be useful to researchers working both on vegetable pathology and pattern recognition, providing a comprehensive and accessible overview of this important field of research [6].

H. Sabrol and S. Kumar (2015) presented a survey of recent studies on the area of plant disease recognition and classification from digital images using image processing and soft computing techniques. The main aim of the paper was to focus on the area of plant pathology recognition and classification only. The paper had omitted the disease severity quantification. Although the paper considered the images of symptoms present on plant leaves and stems only for limiting the survey. Each considered paper in the review represented the comprehensive details of the technical implementation of an algorithm. The algorithm began with digital image acquisition of infected and non-infected plants; performed image preprocessing, differentiated disease infected region from a non-infected region using segmentation, extracted features from segmented images for recognition and classification. This survey was expected to help researchers from plant pathology and pattern recognition field [7].

Some other papers were reviewed to obtain information about the "severity quantification" of leaf diseases. B. Prakash and A.Yerpude(2015) presented a survey on the various types of leaf diseases in plants and their identification process. An identification problem deals with associating a given input pattern with one of the distinct classes. Plant leaf disease identification is a technique where leaf spot disease is identified based on its different morphological features. There are various successful identification techniques like Probabilistic Neural Network, Genetic Algorithm, Back Propagation Neural Network and Principal Component Analysis (PCA). Deciding on the method for identification is often a difficult task because the quality of the results can vary for different input data. Plant leaf disease identification has wide applications in the field of Agriculture to increase the productivity. The goal of this survey was to provide an overview of different identification techniques for plant leaf disease and give the general approach which uses these techniques [2].

Other methods were shown by S. S. Sannakki and V. S. Rajpurohit (2015) who proposed a paper describe an image processing based approach for detection and classification of pomegranate leaf diseases. The approach begins by processing acquired digital images of leaves of pomegranate plant. The enhanced image is segmented using k-means and thresholding based segmentation approaches to extract lesions of disease. Haar Wavelet Transform method extracts a set of visual features of diseased portions. Based on the extracted features set, a Fuzzy Logic classifier identifies the affected disease type and provides treatment measures to control the disease. The advisory may help farmers in effective decision making to protect their crop from diseases, thereby, increasing crop yield[8].

A. K. Dey, et al. (2016) in the proposed paper deals with leaf rot disease detection for betel vine (Piper betel Leaf) based on image processing algorithm. The measurement of plant

features is a fundamental element of plant science research and related applications. The information related to plant features is especially useful for its applications in plant growth modeling, agricultural research and on farm production. Few methods have been applied in leaf rot disease detection for betel vine leaf (Piper Betel Leaf). Traditional direct measurement methods are generally simple and reliable, but they are time consuming, laborious and cumbersome. In contrast, the proposed vision-based methods are effective in detecting and observing the exterior disease features. In the present investigation, image processing algorithms are developed to detect leaf rot disease by identifying the color feature of the rotted leaf area. Subsequently, the rotted area was segmented and area of rotted leaf portion was deduced from the observed plant feature data. The results showed a promising performance of this automatic vision-based system in practice with easy validation. This paper describes the steps to achieve an efficient and inexpensive system acceptable to the farmers and agricultural researchers as well for studying leaf rot disease in betel vine leaf[9].

Some papers show leaf disease detection as a method to decrease agricultural losses. S. D. Khirade and A.B. Patil (2015) proposed that identification of the plant diseases is the key to preventing the losses in the yield and quantity of the agricultural product. The studies of the plant diseases mean the studies of visually observable patterns seen on the plant. Health monitoring and disease detection on the plant are very critical for sustainable agriculture. It is very difficult to monitor the plant diseases manually. It requires a tremendous amount of work, expertize in the plant diseases, and also require the excessive processing time. Hence, image processing is used for the detection of plant diseases. Disease detection involves the steps like image acquisition, image pre-processing, image segmentation, feature extraction and classification. This paper discussed the methods used for the detection of plant diseases using their leaves images. This paper also discussed some segmentation and feature extraction algorithm used in the plant disease detection [10].

Other papers discussed different types of leaf disease classification methods. R. Pagariya and M.Bartere (2014) in the proposed paper contained the survey of various image processing techniques to detect various plant diseases using machine learning. Presently image processing technique is becoming a key technique for diagnosing the various features of the crop. The diseases can affect any part or area of the crop. This paper mainly focused detection of various cotton crop diseases and to classify them. There are so many classification techniques such as k-Nearest Neighbor classifier, k-means Classifier, Probabilistic Neural Network, Genetic Algorithm, Support Vector Machine, and Principal Component Analysis, Artificial neural network, Fuzzy logic. Selecting a classification method is always a difficult task because the quality of result can vary for different input data. This paper provided an overview of different classification techniques used for plant leaf disease classification [11].

R. Masood, et al. (2016) in the proposed paper presented different classifiers that are used to classify such as SVM (Support Vector Machine), K- nearest neighbor classifiers, Artificial Neural Networks, Fuzzy Logic, etc. This paper presented different image processing techniques used for the early detection of different plants diseases by different authors with different techniques. The main focus of this work was on the critical analysis of different plants disease segmentation techniques. The strengths and limitations of different techniques were

discussed in the comparative evaluation of current classification techniques. This study also presented several areas of future research in the domain of plants disease segmentation. Their focus was to analyze the best classification techniques and then fuse certain best techniques to overcome the flaws of different techniques, in the future[12].

G. Li, et al. (2013) proposed that in order to realize accurately calculating and automatically grading of plant disease severity, a single-leaf disease severity automatic grading system based on image processing was developed by using MATLAB GUIDE platform. Using this system, the single-leaf disease severity could be automatically assessed and graded via image development technologies including segmentation processing technologies of plant disease images and related data mining technologies. Structural diagram of the system, algorithms used in the system and realization of the system functions were described. The problems in the current version of the system were discussed and further research on this subject was suggested. The usefulness and adaptability of the system were evaluated using the images of grape downy mildew caused by Plasmoparaviticola. The results showed that the effectiveness of the system was favorable with high accuracy [13].

Generally, papers describing leaf disease detection methods used a neural network for classification. S. Kumar and R. Kaur (2015) in the proposed paper held a survey on plant leaf diseases classification using image processing. Digital image processing has three basic steps: image processing, analysis and understanding. Image processing contains the preprocessing of the plant leaf as segmentation, color extraction, diseases specific data extraction and filtration of images. Image analysis generally deals with the classification of diseases. Plant leaf can be classified based on their morphological features with the help of various classification techniques such as PCA, SVM, and Neural Network. These classifications can be used to define various properties of the plant leaf such as color, intensity, dimensions. Back propagation is most commonly used a neural network. It has many learning, training, transfer functions which is used to construct various BP networks. Characteristics features are the performance parameter for image recognition. BP networks showed very good results in the classification of the grapes leaf diseases. This paper provided an overview of different image processing techniques along with BP Networks used in leaf disease classification [14].

Some papers even used more than one method for classification. Like the papers below use both k-means and neural network together, obtaining very high accuracy. S. Gharge and P. Singh (2016) proposed that in agriculture, Plant disease is one of the major congestion for increasing productivity and quality of food. False diagnosis of plant disease causes excessive use of pesticides which in turns affects the quality of the crop. In this paper, we proposed an algorithm for detection of Soybean disease and its severity. The research paper focuses on classification and infected area estimation of Frogeye, Downy mildew and Bacterial Pustule disease of Soybean. In this proposed approach, Image enhancement technique for enhancing the image quality is used. Then k-means segmentation algorithm is applied to separate infected cluster from the leaf. Neural Network is used to classify Frogeye, Downy mildew and Bacterial Pustule. The accuracy of 93.3% is achieved for 30 images. After classification area estimation of infected area is performed [15].

I. E. Massi, et al.(2017) in their proposed paper presented a pattern recognition system for the identification of the vegetable crops diseases from images. The proposed system was based on three main phases: Segmentation, feature extraction and classification. The segmentation of the images was carried out using k-means clustering method. Then, three types of features were extracted from the segmented images including color, texture and shape. These features were used for training and classification using neural networks. The tests of this study were carried out on 300 images of three vegetable crops diseases (Early blight, Late blight and Powdery mildew). The results, with a recognition rate of 95.3 %, showed that the proposed system would be interesting to use as means of diagnosis of vegetable crops diseases [16].

Digital image processing has three basic steps: image processing, analysis and understanding. Image processing contains the preprocessing of the plant leaf as segmentation, color extraction, diseases specific data extraction and filtration of images. Image analysis generally deals with the classification of diseases. These classifications can be defined various properties of the plant leaf such as color, intensity, dimensions. Classifiers are the software routine written on the platform to define certain features for classification of the images. Some of the linear and non-linear classifier used for image classification are: K-nearest neighbor, Radial basis function, Probabilistic Neural Network (PNN), Convolutional neural network, Support vector machine and Back propagation network. With the help from any of these techniques, the automation in plant leaf disease detection can be achieved. Any platform such as MATLAB can be used to train and test these classifiers.

3. PROPOSED METHODOLOGY

The Image analysis in agriculture is extensively applied to agricultural science, and it has great perspective especially in the plant protection field, which ultimately leads to crop management.

There are various factors which affect feature value such as; the optical & mechanical property of camera, lighting condition of object, scanner resolution (if scanner is used for data acquisition). Due to small variation in the value of the feature, it is almost impossible to find an exact match between images database and the input image. Therefore, a technique is required where the small variation of extracted feature can be considered for comparison with existing images of image database. For identification of image, a marginal variation in feature value is taken and again it is compared to the formulated cluster and recognizes the image.

The various image processing and neural network approaches can be applied for the identification of the leaf diseases on the plant. A projected approach for this identification is shownin the fig.3 Plant leaf disease identification process.

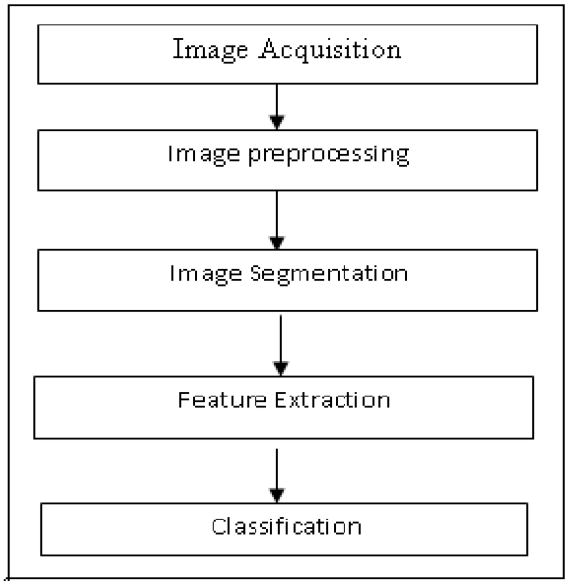

Fig. 3: Plant Leaf Disease Identification Process

A. Image Acquisition: Initially, the digital images are acquired from the circumstances using a digital mobile camera or digital camera and given as input to the identification system. This is the image in which the leaf disease has to be identified by the system.

B. Image Pre-processing: Image pre-processing tasks are the initial stage before feature extraction. There are three steps of image preprocessing, i.e., image cropping, image converting and image enhancement. The image is cropped on leaf diseases area, and then converted to gray levels. In this process, the noise is eliminated from the captured image to enhance the image quality.

C. Image Segmentation: Image segmentation is the methodology of apportioning a digital image into different fragments (sets of pixels, otherwise called super pixels). The objective of segmentation is to improve and/or change the representation of an image into something that is more significant and less demanding to examine. The consequence of image segmentation is a situated of sections that aggregate cover the whole image or a set of forms removed from the image. Each of the pixels in a locale is comparative as for some trademark or registered property, for example, shading, force, or surface. Nearby districts are essentially diverse as for the same characteristic(s). At the point when connected to a pile of images, normal in restorative imaging, the subsequent forms after image segmentation can be utilized to make 3D recreations with the assistance of interpolation calculations like marching cubes.

D. Feature Extraction: Feature extraction is a special form of dimensionality reduction. At the point when the information to a calculation is complex, it would be impossible be transformed and it is suspected to be exceptionally repetitive, then the data information will be changed into a decreased representation set of features (likewise named features vector). Changing the information into the set of features is called features extraction.

E. Classification: Image classification, a theme of example distinguishable in PC vision, is a methodology of arrangement in view of relevant data in images. "Logical" implies this methodology is concentrating on the relationship of the adjacent pixels, which is additionally called a neighborhood. The objective of this methodology is to arrange the images by utilizing the logical data. According to the classification result the disease of the leaf is identified and the appropriate action can be taken by the farmers in the initial stage of disease for its control [2].

Software Used:

A software routine can be written in MATLAB that would take in .mat files representing the training and test data, train the classifier using the 'train files', and then use the 'test file' to perform the classification task on the test data. Consequently, a MATLAB routine would load all the data files (training and test data files) and make modifications to the data according to the proposed model chosen.

4. CONCLUSION

Plants are the primary source to solve the problem of food starvation, air pollution, global warming, etc. Agriculture production is the means to feed ever-growing populations and is the major source of income for the majority of the rural poor. Threats by invasive pathogens to plants are increasing day by day. The damage caused by emerging, re-emerging, epidemic and endemic pathogens, is becoming a nightmare in plant systems leading to potential loss economically. 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 degrade 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 means of analyses of digital images of crop samples. The identification of the visual symptoms of plant diseases by means of a machine vision system and providing a solution for disease control 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.In a word, the image pre-processing can make extracting of characteristic parameters not to be affected by background, shape and size of leaf, light and camera and make a good foundation for effective characteristic parameters for the disease diagnosis, as well as setting up pattern recognition system.

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