Image Segmentation Techniques for Leaf Disease Detection and Grading: An Analysis and Comparative Study

[1]R.Hepziba Gnanamalar, [2]Dr.T.Devi
[1]Ph.D Research Scholar, [2]Professor and Head
[1&2] Department of Computer Applications, Bharathiar University, Coimbatore – 641 046.

Abstract : Agriculture can reduce poverty, increase incomes and expand food security for 80% of the world's poor, who lives in rural areas(FAO of UN, 2019). Plants exist everywhere and leaf is a plant organ, exposed to the external environment. Plants are important for the planet and for all living things. Plants are great sources of fiber and 70,000 to 80,000 plants and leaves species are used for medicinal or aromatic purposes globally. India with its ecological, geographical and climatic diversities is perhaps the richest nation with a vast herbal medicinal wealth and 15000-20000 plants have good medicinal value. These plants life begins from a seed but also plants health can be identified through the leaves. If leaves are not healthy, the yield and productivity from plants gets affected and thus affects the society. Image processing and segmentation play vital role in plant disease detection research. The accuracy of segmentation establishes the success of the image processing research, which penetrate as energetic role in arena of agriculture. The paper provides an introduction about the image segmentation and summarises the important of plants. Especially various image segmentation methods, comparison and image segmentation roles in leaf disease area segmentation and grading are discussed in this paper.

Index Terms **- Image Segmentation, Plant leaf disease, Disease grading, Image Disease segmentation.**

I.INTRODUCTION

India with its ecological, geographical and climatic diversities is the richest nation with a vast herbal medicinal wealth and 15000-20000 plants have good medicinal value. More than that, plants are a great source of medicine even for life-threatening diseases, excellent natural sources for preventing diseases and leaves are one of the healthy foods. Plants are the ultimate source of food and metabolic energy for nearly all livings and it produces grains, fruits, and vegetables for the human lives. Leaves are the primary way of the plants to interact with the atmosphere and to take care of their basic needs. Leafy vegetables are good sources of vitamins such as vitamins A, vitamins C and vitamins K and minerals such as iron and calcium. Not only foods, plant products plays dynamic role in the human daily life which includes wood products, fibers, drugs, oils, latex, pigments, and resins. Coal and petroleum are fossil elements of plant origin. Thus plants offer plenty of uses to the people not only sustenance, it provides shelter, clothing, medicines and fuels. And also, plants fascinate carbon dioxide and discharge oxygen from its leaves, which all livings need to breathe. So, leaf disease detection as well as grading research is necessary and effective for the society as well as for farmers. Next section elaborately explains about plant disease research and Image segmentation techniques. The paper discusses about various image segmentation techniques and the paper is classified into five sections. Section II the details the study of image segmentation. Section III briefs about various image segmentation techniques. Section IV compares the image segmentation techniques to detect and grade the plant leaf disease. The final section summarises the image segmentation methods for leaf disease detection.

II. Image Segmentation

Image segmentation is a substantial technique in the image processing and also it is a challenging task on an image. Segmentation converts the image representation from complicated one to analytical and flexible form. Satisfied segmentation is obtained from various techniques such as edge-based segmentation, region-based segmentation, morphological operations, thresholding and clustering methods. Image segmentation used for various research areas such as vehicle tracking, medical imaging, face reorganization, biometric applications and disease detection in agricultural arena. Image segmentation is a key process of the image analysis and image comprehension. Image segmentation is partitioning an image into multiple segments and to get meaningful region for image analysis. An image is parted into regions called as segments (Sujata Saini et al, 2014) and image segmentation is a process of partitioning pixels of an image to different regions based on specific information such as intensity, texture or color. For a segmented image, pixels in one region are similar to each other according to a homogeneity criterion, yet pixels in different regions are heterogeneous. Image segmentation is a major step in image processing, computer vision and deep learning. The segmented images are the input to high level image processing techniques such as feature extraction, object detection, image recognition and classification. Since this process divides an image into several homogeneous regions and helps to find regions of interest, images become easier to manipulate and more meaningful for the high-level tasks (Yuyu Liang, 2014).

III. IMAGE SEGMENTATION TECHNIQUES

Segmentation is the classifications of an image into meaningful data for easy analysis of the image. Various Image segmentation methods are used to detect the diseases and to measure the disease severity, which will helps to increase the crops and reduce human error and time. Sugarcane is mostly affected by fungal disease which appears no ears on the leaves like brown spots. Triangle thresholding method is used to detect brown spot disease area on the sugarcane leaf. Triangle thresholding is to draw the triangular lines in the leaf to calculate thresholding value to segment the leaf disease area, but this method requires 18 W cool light bulbs and light filters to capture sugar cane leaf. Histogram based triangular segmentation methods are used to analyse brown spot disease on sugarcane plant and sugarcane leaf disease severity are assessed by calculating the quotient of diseased area and leaf areas (Sanjay B. Patil, 2011).

Kernel Descriptor and K-Means algorithm segmentation are used to identify the plants diseases. Kernel Descriptor converts the leaf images into gray scale and resizing the leaf image without altering the shape of leaves which plays an essential role in the identification among the variety of leaves (Thi-Lan Le et al, 2014). Nandhini et al (2016) proposed binary decomposition and otsu thresholding segmentation methods to predict the paddy plant disease based in the threshold values. Gray-level values are used to acquire the set of T threshold values which is used to predict the threshold that reduces input image intra class variance. Kittipong powbunthorn et al (2012) developed segmentation methods for assessment of brown leaf spot Disease in Cassava in which thresholding is done using Otsu method and disease spot regions are segmented by analysis of the histogram based on HSI (Hue, Saturation and Intensity) color space. Thus the plant diseases are assessed by calculating the quotient of disease spot and leaf areas. Leaf spot diseases are segmented through Region of Interest (ROI) segmentation technique. ROI segmentation is performed by three steps, first step is Region is obtained by masking. Second step is morphological opening to eliminate the healthy area on the plants and final step is to subtract narrow parts of the leaf. ROI in color space is used to analyse and detect the disease on plants (Jayme Garcia, 2014).

K-means clustering is used to split the leaf image into four clusters. One or more clusters might have disease on the leaf, which indicates disease severity and leaf might get affected by one or more disease. The K-means clustering algorithm tries to categorize pixels based on a set of features into K number of clusters. The categorization is done by minimizing the sum of squares of distances between the objects, cluster or cluster centroid. Based on the cluster and cluster centroid, disease areas are predicted (Sachin.B.Jadhav, 2015). Soya bean fungal diseases grading is done using thresholding segmentation technique. Thresholding values are obtained by the L*a*b color space. L* for lightness from black and white, a* from green to red and b* from blue to yellow (Evy Kamilah Ratnasari, 2014). Segmentation techniques are processes used to refurbish the portrayal of a picture into a meaningful form. Segmentation is done by shading change into YCbCr and bi-level thresholding. Shading and thresholding are essential approach for segmentation and the leaf image is fragmented into two diverse regions in bi-level thresholding, which is used to predict the disease in Citrus plants (Rajeshwari, 2018). Images of disease affected lemon leaves are segmented using of gray level threshold segmentation and the segmented images are given as input for canny edge detection algorithm to predict the disease (N.Satya Priya, 2016). Gaurav Thakre (2017) proposed region growing segmentation to identify plant disease. K-means clustering technique and euclidean distance are used after region growing to grade the plant disease (Gaurav Thakre, 2017).

IV. COMPARATIVE STUDY

Various image segmentation techniques are compared and the comparison is given in Table.1.The image segmentation methods can be compared based on 1.Development environment 2.Applications, 3. Whether it supports android environment or not 4.Whether it uses cloud technology or not. 5. Whether it will grade the disease or not 6. It requires expertise or not 7. Need of internet 8.Limitations. Even though the segmentations lead to identification of the disease severity, it has certain limitations and demerits out of ten methods, only three methods are used in android platform. The development environment included MATLAB and Android. Nearly 75% researchers used MATLAB. K-Means algorithm and thresholding based on l*a*b segmentation methods needs experts opinion to find out the leaf disease grading, therefore the existing methods are not automated and they do not reduce human's efforts.

Image segmentation is a driving factor for the success of the leaf disease grading research, but very few methods Kernel Descriptor (KDES) K Means algorithm, Region growing and Thresholding based on L*a*b can be used in android mobile platform. Kernel Descriptor (KDES) on K Means algorithm is used for leaf based plant identification but not for grading the leaf disease. Thresholding based on L*a*b segmentation method is used to grade the soya beans fungal disease in the android platform but it requires expert's opinion and high processing time to produce the results. Region growing and K-Means clustering are used for leaf disease detection but not for grading. The existing segmentation methods do not provide efficient results and not user friendly. Cloud based research is costly. Flatbed scanner and unique environment are necessary for certain methods. Hence, the comparative study concludes that there is a need for a novel segmentation method to develop new environment for disease grading, which should overcome the limitations of existing methods and improve the performance.

S.No	Technique	Applications	Development Environment	Support for Android Platform	Support for Cloud	Disease Grading or not	Need of Local Server	Need of Internet	Need of Experts required	Limitations
1	Triangle thresholding method	Brown spot disease detection in sugar cane leaf	MATLAB	No	No	Yes	No	No	No	Consumes time and requires 18 W cool light bulbs and light filters
2	Kernel Descriptor (KDES) and K Means algorithm	Leaf based plant identification	Android Studio	Yes	No	No	Yes	No	No (Other user opinion needed)	User contribution is required
3	Threshold Binary Decomposition by using Otsu thresholding	Paddy leaf disease grading	MATLAB	No	No	Yes	No	No	No	Low Accuracy
4	Otsu thresholding	Brown leaf spot disease grading in cassava	MATLAB	No	No	Yes	No	No	No	Count only the dotted disease
5	Thresholding based on ROI	Late leaf spot grading in plants	MATLAB	No	No	Yes	Yes	No	No	Flatbed scanner is required
6	K-Means segmentation	Soya bean leaf disease grading	MATLAB	No	No	Yes	No	No	Yes	Time consuming and cost effective
7	Thresholding based on L*a*b	Fungal disease grading in soya bean plants	Android Studio	Yes	Yes	No	No	Yes	Yes	Processing time is high
8	YCbCr and bi-level thresholding	Citrus Leaf Disease Detection	MATLAB	No	No	No	Yes	No	No	High Pre-processing is required
9	Gray-level threshold segmentation	Disease detection in Lemon Leaf	MATLAB	No	Yes(Database required)	No	Yes	Yes	No	More storage space is required
10	Region growing and K-Means Segmentation based on colors	plant disease detection	Android Studio and SQLite	Yes	No	No	Yes	No	No	Laboratory condition using a digital camera

Table 1. A comparative study on Image segmentation techniques for leaf disease detection and grading

V. CONCLUSION

This paper discusses the vital role of Image Segmentation techniques for detecting leaf disease and its grade. The goal was to compare the environment in which the techniques are developed, limitations and requirements of the segmentation techniques. The comparative study on Image Segmentation techniques for leaf disease detection and grading shows that there is no support for android platform for any techniques except Kernal Descripter (KDES) and K-Means segmentation algorithm, thresholding based on L*a*b, Region growing and K-Means segmentation based on colors but Kernel Descriptor(KDES) and k-Means algorithm is in need of local server and user involvement whereas thresholding based on L*a*b needs internet connectivity and expert advice. Region growing k-means segmentation based on color also needs a local server. Hence, there is a place for the development of new technique in android platform that does not require any local server. And it is also shown that the need for an expert opinion would be inconvenient for farmers because expert may not be available all the time. This paper on comparative study of image segmentation techniques for leaf disease detection and grading further shows that developments and improvements are required for leaf disease detection and grading in the android platform to increase the productivity of the plants.

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