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Plant Disease Leaf Image Segmentation Using K-Means Clustering Based on Internet of Things

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***Abstract* – The internet of things has been employed to recognize and monitor the plant diseases, in which the key process is the plant disease leaf image segmentation. Based on K-means clustering, a plant disease leaf image segmentation method is proposed in this paper. The plant disease leaf images are collected by the Internet of Things (IOT). Select an initial partition with k clusters, and a new partition is generated by assigning each, pattern to its closest cluster. Then compute new clusters. After several iterations, the spot image is obtained. The experimental results show that the proposed method is a robust for plant disease leaf image segmentation.**

***Keywords* – Agricultural Internet of Things, Plant Disease Monitoring, Plant Disease Leaf Image Segmentation, K-means Clustering, Internet of Things (IOT).**

I. Introduction

The conventional method of plant disease detection using naked eye observation method is rude and is non-effective. Using computer the plant disease detection is efficient and is not time consuming. On the basis of plant disease leaf symptoms and with the computer digital image processing methods, the recognizing plant disease becomes easier. Detection and recognition of plant diseases using machine learning method and compute is very fruitful in identifying diseases by plant leaf symptoms at its earliest [1,2]. The obtained plant disease leaf images were composed of diseased regions and normal leaf regions. In order to extract effective features, it is first step to segment the disease regions from the leaf color images. Color segmentation of leaf image is a crucial operation in leaf image analysis and final plant disease recognition. Leaf image segmentation usually includes binary segmentation and color segmentation. The former is to extract shape features from the segmented images and the latter is to extract color features and texture features from the segmented images [3]. Many leaf image segmentation methods have been presented, which can be classified into the following basic concepts: edge, threshold, pixel oriented, contour-oriented, region-oriented, model-oriented, color oriented and hybrid [4]. Currently, the methods used for plant disease image segmentation are edge detection method, segmentation method based on statistical pattern recognition, fuzzy C-means clustering, K-means clustering, Otsu, etc. [5-7]. All leaf image segmentation methods can be generally divided into two categories: supervised and unsupervised. The first category is not applicable to remote sensing because an optimum segmentation is difficult to obtain. Moreover, available segmentation methods have not been thoroughly tested for remotely sensed data. For comparison purposes, it is possible to proceed with the plant disease classification and then indirectly assess the segmentation step through the produced classification accuracies. K-means clustering and Otsu algorithms are used to segment plant disease leaf images [8-10]. These algorithms are unsupervised real-time clustering algorithms. The basic idea of two algorithms is to identify the spot regions where the different colors belong to using the different colors in the image color space, so as to achieve the purpose of image segmentation. The implementation process of these segmentation methods has been used in plant leaf image segmentation. For image segment based disease recognition, the leaf images that need to be classified are segmented into two homogeneous areas with similar pixel information firstly, and the image segments' features are extracted based on the specific requirements of ground features classification. The color homogeneity is based on the standard deviation of the spectral colors, while the shape homogeneity is based on the compactness and we should choose a scale value as large as possible to distinguish two different regions: spot and normal; some color criterions are possibly used [11-13]. Because the pixel information is the most important in imagery data, the quality of segmentation would be reduced in high weightiness of shape criterion. The Internet of Things (IOT) is a worldwide network of intercommunicating devices, which can integrate the ubiquitous communications, pervasive computing and ambient intelligence. IOT has three layers, namely, sensor layer, transport layer, application layer. IOT means that all appliances, furniture, clothes, vehicles, roads and smart materials and so on, are readable, recognizable, locatable, addressable and/or controllable via the Internet. This will provide the basis for plant disease recognition based on the disease leaf images. Often the farmer's hard works are destroyed by diseases and pests and they suffer huge monetary losses. To prevent such situation agriculture IOT has a system which monitors and scans the environmental parameters & plant growth, further this data is utilized by pest control sensors which is capable of predicting pest behavior. This information can be used by farmers to reduce damage done by pests on a large scale. Agriculture IOT helps in increasing crop productivity by way of managing and controlling the diseases and pests, and is also laced with monitoring plant disease tool to prevent the disease from spreading by smartly analyzing the disease information of crop leaf images and adopting optimal preventive treatment measure in time. In key process of plant disease recognition by agriculture IOT is the leaf image segmentation [14]. In this paper, using the K-means clustering algorithm, binary segmentation and color segmentation of the cucumber leaf images are conducted. The results show that this method could effectively segment the diseased regions from the color images of the diseases with robustness.

The rest is organized as follows: Section 2 introduces agriculture IOT. Section 3 describes the method of leaf image segmentation based on color with K-means clustering. Experimental results obtained with suggested method are shown in section 4. Finally, section 5 concludes with some final remarks.

II. Agriculture Internet of Things

IOT is one of the popular focuses of research in recent years. Through IOT, many studies have brought innovations and convenience for agriculture. But in the sericulture industry, the practical application of IOT is less. This paper introduced the studies and application of the IOT in agricultural, referred to these previous studies, analyzed where IOT could be applied in sericulture industry. Agriculture IOT ensures accurate and timely communication of real time data or information related to dynamic agricultural processes like plantation, harvesting, weather forecasts, soil quality, and management of disease and pest etc. Farmer's with availability of such important real time information in advance are able to plan their course of activities pre-hand and take corrective/preventive measures for disease and pest contingency. Agriculture IOT aims not only at attaining optimum food productivity and Food security along with quality matching the standards but also aims at disease and pest management etc. To avoid the crop under-production, agriculture IOT has a system that monitors the various environment factors, such as temperature, humidity, light, carbon dioxide, rain, wind direction and cloud etc., by using a lot of sensors. No-line sensors have long been used as a tool to extract plant growth and yield information for many crops, which can provide quantitative and timely information on crop diseases during the growing season and have been used to monitor plant growth conditions and obtain crop yield information for several years. A variety of agriculture IOT systems are available for data collection related to the plant diseases.

III. Plant Leaf Image Segmentation

Image segmentation is an important process in many computer vision and image processing applications, which divides an image into a number of discrete regions such that the pixels have high similarity in each region and high contrast between regions. Properties like gray-level, color, intensity, texture, depth or motion help to recognize similar regions and similarity of such properties, can be used to construct groups of regions having a specific meaning. Segmentation is a valuable tool in many fields including industry, health care, image processing, remote sensing, traffic image, content based image, pattern recognition, video and computer vision etc. The leaf image segmentation method can be found in application involving the disease detection and plant recognition. Now many researches have focused on the gray-level segmentation of leaf image obtained by IOT, in which the color leaf images are so quite complex but carry most of the disease information. There are many clustering methods developed for plant leaf image segmentation. K-means is the clustering algorithm used to determine the disease leaf image pixel groupings present in an image set. Each pixel in the image is then assigned to the cluster whose arbitrary mean vector is closest. The procedure continues until there is no significant change in the location of class mean vectors between successive iterations of the algorithms. As K-means approach is iterative, it is computationally intensive and hence applied only to image subareas rather than to full scenes and can be treated as unsupervised training areas.

IV. Experiments

The plant disease leaf images captured by agriculture IOT are with very complex background and noise, so the leaf image segmentation is not easy by many segmentation image methods. In this section, a detail segmentation steps by applying nonlinear k means algorithm are showed to find out the infected region of the disease leaf image.

Firstly, the RGB color leaf images are captured by IOT video sensor with required resolution for good quality. A disease leaf image database is constructed for the disease recognition. The image database itself is responsible for the better efficiency of the image processing and pattern recognition which decides the robustness of the algorithm. Image preprocessing and segmentation steps are to improve image data that removes background, noise, suppress undesired distortions and also segment the spot part, which can enhance leaf image features for disease recognition and analysis. The input RGB color image captured by IOT is converted into other color spaces such as HIS and CIELAB. Because RGB is color dependent space model but HSI and CIELAB are color independent space model and this are also derived from human perception. The various experiment carried out on the above said imagery in MATLAB v7.5. The steps and corresponding results are as follows.

Step 1 Read image. Read each image from the leaf image database which is in .JPEG format. Consider the RGB image as an input in segmentation process. The RGB image is converted to HSV color space.

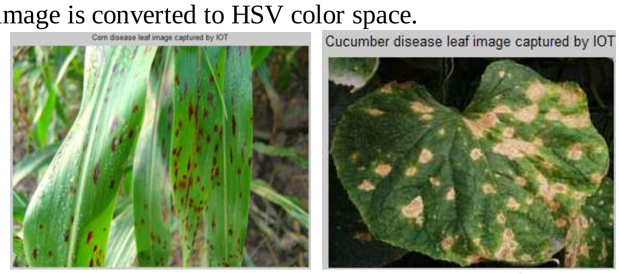


Fig. 1. Original corn and cucumber disease leaf images captured by IOT

Step 2 Convert Image from RGB Color Space to L*a*b* (also known as CIELAB or CIE L*a*b*) Color Space. There are three color formats: white, blue, and pink. These colors can be easily visually distinguished from one another. The L*a*b* color space enables to quantify these visual differences. The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. All of the color information is in the 'a*' and 'b*' layers. The L*a*b* color space is derived from the CIE XYZ tristimulus values, which can be used to measure the difference between two colors using the Euclidean distance metric. Convert the image to L*a*b* color space.

Step 3 Classify the Colors in 'a*b*' Space Using K-Means Clustering. Clustering is to separate groups of objects. K-means clustering treats each pixel as having a location in space. It finds partitions such that pixels within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. K-means clustering requires that one specify the number of clusters to be partitioned and a distance metric to quantify how close two objects are to each other. Since the color information exists in the 'a*b*' space, the spot image are pixels with 'a*' and 'b*' values, where the K-means is to cluster the pixels into three clusters using the Euclidean distance metric.

Step 4 Label Every Pixel in the Image Using the Results from K-means. For every pixel in the input, K-means returns an index corresponding to a cluster. Label every pixel in the image with its cluster index.

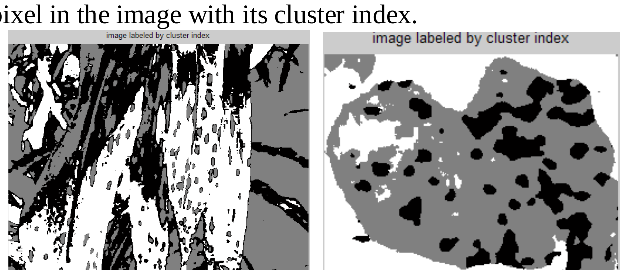
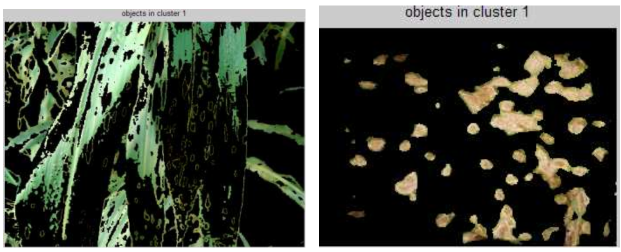


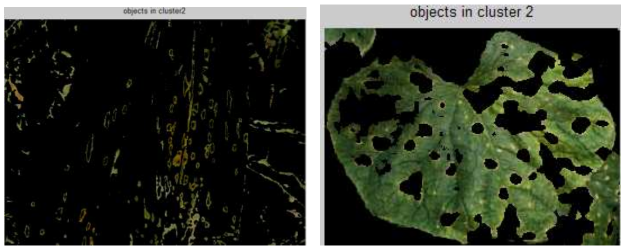
Fig. 2. Label every pixel in the image with its cluster_index

Step 5 Create Images that Segment the Image by Color. Using pixel labels, we have to the pixels can be separated in image by color, which will result in five images.

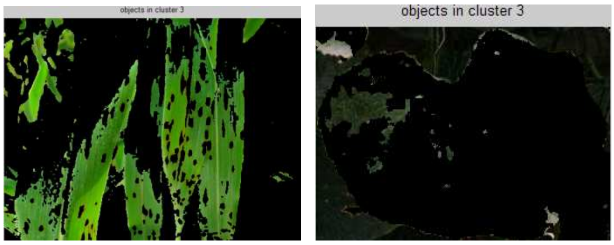
Step 6 Segment the Nuclei into a Separate Image. Then programmatically determine the index of the cluster containing the blue objects because K means will not return the same cluster_idx value every time. We can do this using the cluster center value, which contains the mean 'a*' and 'b*' value for each cluster.



(A) Use k-means to cluster the objects into luminosity layer 'L*' cluster using the Euclidean distance metric



(B) Use k-means to cluster the objects into chromaticity-layer 'a*' cluster using the Euclidean distance metric



(C) Use k-means to cluster the objects into chromaticity-layer 'b*' cluster using the Euclidean distance metric

Fig. 3. Corn and cucumber disease leaf images are segmented by K-means clusting into three clusters using the Euclidean distance metric

Notice that there are dark and light blue objects in one of the clusters. You can separate dark blue from light blue using the 'L*' layer in the L*a*b* color space. The cell nuclei are dark blue. Recall that the 'L*' layer contains the brightness values of each color. Find the cluster that contains the blue objects. Extract the brightness values of the pixels in this cluster and threshold them using im2bw. The index of the cluster containing the blue objects is determined experimentally because k-means will not return the same cluster_idx value every time and the blue cluster has the smallest cluster_center value.

The segmentation process presents a clustering mechanism for high resolution images in order to improve the precision and processing time. Plant image, however, always contain complicated background objects that interfere with the examination process and must be removed from the image prior to species classification. Many approaches have been already introduced for image segmentation. The most popular method for image segmentation is K-means algorithm. It is a widely used algorithm for image segmentation because of its ability to cluster huge data points very quickly. The function of clustering is to group image pixels where the related feature vector produces the similar images. One type of hierarchical clustering is widely applied for image segmentation.

V. Conclusions

Plant leaf image segmentation is a fundamental task in agriculture computer graphics vision. Although many methods are proposed, it is still difficult to accurately segment an arbitrary image by one particular method. Using color based image segmentation; it is possible to reduce the computational cost avoiding feature calculation for every pixel in the image. Although the color is not frequently used for image segmentation, it gives a high discriminative power of regions present in the image. This kind of image segmentation may be used for mapping the changes in land use land cover taken over temporal period in general but not in particular.

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