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Image Segmentation Methods: A Comprehensive Survey

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Abstract:

Image Segmentation is important task in computer vision. This paper discusses the various methods for segmentation. Most segmentation algorithms are developed for gray level images. These algorithms developed for gray level images can be applied to color images by modifying them to handle color images of by converting color images into gray level image. With the improvements in computing field color image segmentation has also gained momentum. But nevertheless gray scale image segmentation still predominantly used because of its ease in usage. This paper explores both gray level image segmentation and color image segmentation. The field images of theleaves were taken and different methods were tried the findings are recorded and discussed.

Introduction:

There are various types of images like light intensity image, Magnetic Resonance Image, thermal image, radiographic image etc. Most common image is the light intensity image which is also the focus of this paper. Image is represented by a2-D function,where (x, y) represents the spatialcoordinate and $f(x, y)$ gives the feature value at (x, y). Digital image is represented by a2-Ddiscrete function $f(x, y)$. It is also possible to view the digital image as a matrix whose element are called pixel and its value identifies the intensity level [1][7]. Segmentation of an image is the essential and critical step of Computer vision.Segmentation is the process of

partitioning the image into regions which are non-overlapping and each region is homogenous. The union of two adjacentregions is not homogenous. Image segmentation is formally defined as follows, if F is the set of all pixels in an image and $P()$ is a uniformity predicate defined on groups of connected pixels, then segmentation is a partitioning of the set F into subsets or region $(S_1, S_2, S_3 ..... S_n)$ which are connected [1]. The regions thus obtained should satisfy the following conditions:

1. $\bigcup_{i=1}^{n} S_i = F$
2. $S_i \bigcap S_j = \phi, i \neq j$.
3. $P(S_i) = true$ for all regions of S_i.
4. $P(S_i \bigcup S_j) = false$, when S_i is adjacent to S_j .

Segmentation is used for identifying the Region of Interest in an image. There are different techniques available to perform segmentation. Image segmentation methods are categorized in to Threshold based method, Clustering based methods, edge detection, ANN, Fuzzy based algorithms,and Morphology based method.

Thresholding based methods have been modified a lot from local thresholding to global thresholding. Well Known thresholding method is the Adaptive thresholding method proposed byOtsu. Instead of thresholding based on the intensity value of the pixel, the entropy value can be used for segmentation. Literature is also available for fixing threshold using soft computing techniques which leads to better segmentation [11].

In clustering based methods different algorithms have been proposed. Algorithms like K-means clustering have been utilized for segmentation purpose[7][9][10].

Active contour and Level Set Segmentation which uses Partial Differential Equation have also been proposed and found to be effective in some cases. Literature is also available for transform based segmentation. Transforms like Wavelet, Watershed and Hough have been used by many People achieve better segmentation for some applications [5].

Literature is also available for a combination of known segmentation technique for better result. These techniques use more than one segmentation algorithm in a sequence to produce a final segmentation result which is in most cases better than a single technique applied for segmentation. Edge detection filters like Sobel, Prewitt and Canny produce a result in most cases is very basic. It is required to try other algorithms on top of this to get better segmentation especially morphology operators to generate a closed region.

Many gray scale segmentation Techniques has been adapted for color images. Easiest way of segmenting color images is to convert it into a gray scale image and apply any of the gray scale segmentation algorithms. Color images use

different color models to represent them. There are some common color models which are used in representing color images. Models available in the literature are RGB, CMYK, HSV, HSI, XYZ, L*a*b* etc. By converting the color image from one model to other model may give a better segmentation. Most commonly used is the RGB to HSV and L*a*b* conversion. The following section discusses various methods for segmentation in detail for segmenting plant leaves from the field image obtained using a digital camera.

Gray level image segmentation:

There are lots of methods available for segmentation of gray level images, of which, this section discusses a few important and commonly used methods. These methods were found to be good enough in many cases for different classes of images. The leaf images obtained are color images; nevertheless this paper explores the methods used for gray level image segmentation.

1. Edge based Segmentation:

Early literature on segmentation used edge based segmentation. This is a well-developed domain in the field of image processing. Filters like Roberts, Prewitts, Sobel and Canny are used for identifying the edges. These filters basically look for lines in different orientation and hence they are useful in identifying manufactured object. Of these filters canny filter is of interest because it can identify edges which are arbitrary in nature. But only these filters alone cannot solve our segmentation problem because the processed image may not contain any closed area. So it is mandatory that after applying this filter we apply some morphological filters to find the closed area. These edge filters uses the property of gradient to locate the edge pixels in a given image. These filters calculate the gradient to identify the edge pixels [13]. These filters can be used only when the background is of constant intensity. But the cases where the background is not of constant intensity these filters fall short of giving a segmented region. The focus of this work is on segmenting the leaf from the field image taken in which the background is not constant. Even though the background is not constant these filters were tried along with some morphological operators to produce a segmented result. The field image of the leaf which is given as input is shown in Fig.1. The resultant segmented output is shown Fig.2. was obtained using a canny filter.

Fig. 1 Original image

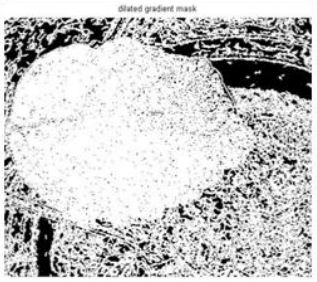

Fig. 2 Canny Edge Detector

2. Texture based segmentation:

Texture is an important property of an object which can be used to identify the region of interest or the object in an image. Statistical property like standard deviation, range and Entropy can be used to identify the region of interest. Here again the morphological operators are applied after segmentation to identify the closed region because the texture based segmentation also gives the result in which the region of interest is not a closed region. Entropy based segmentation was carried out and the result is shown in Fig3.

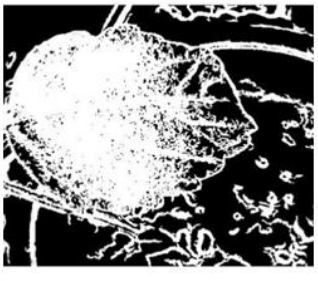

Fig.3 Entropy Based Segmentation

3. Threshold Based segmentation algorithms:

These set of algorithms the region of interest is extracted by fixing a threshold value. The pixel whose intensity is above the threshold is grouped together to create a segmented region. The biggest question in threshold based segmentation algorithms is fixing the threshold value. The threshold can be a local threshold or global threshold. The value of the threshold used for segmentation can be held static. Different statistical parameter like average, median etccan be used for fixing the threshold value. The threshold value can be adaptive also. In Otsu's algorithm the threshold is adaptive i.e., the threshold value is updated every time as the algorithm proceeds. This gives a better segmentation than fixed threshold value. The output obtained is given in Fig.4

Fig 4 Otsu's algorithm

Color Image segmentation:

Amateur images obtained are mostly color images obtained using a normal camera. The field image of the leaf obtained is also a color image. So it is apt to explore the algorithms for segmenting color images also.

1. Segmentation using K means clustering:

Clustering is technique which is used for grouping of pixels in which each cluster will have pixels with similar property. This technique can be applied to color images to identify the region of interest and the process involved is simple. There is a need to convert the image in RGB color model into L*a*b* because It allows us to quantify the visual difference. This enables in better clustering.L*a*b* model has a luminosity component 'L*', chromaticity components 'a*' and b*. Chromaticity component a* represents the location of the color along the red-green axis, and chromaticity component 'b*' indicates the location of the color along the blue-yellow axis. The entire color information of the image is represented by the chromaticity components a* and b*. This helps in calculating the Euclidean distance metric between two colors which isused for clustering. So initially the image is converted from the RGB model to L*a*b* color model. K-means clustering algorithm is applied to the resulting image in

L*a*b* model. The clustering is done based on Euclidian distance to produce the segmented result. The result of this algorithm is given in Fig.5

Fig 5 K-means Clustering

2. Segmentation using Fuzzy C-means clustering:

This clustering mechanism uses the concept of fuzzy logic to produce the segmentation result. This method is more useful when the image has noise in it. The field image taken may have a small amount of noise due to the presence of soil sticking underneath the leaf or a small hole in the leaf due to disease or pest. This may not be there in all the images obtained in the field. So filtering of noise is not required in all cases. This leads to a situation where the segmenting algorithm should be capable of handling the noise if present and produce an effective output which can be used for further processing. Fuzzy C-means clustering algorithm can effectively handle this noise to produce a segmented output. The original color image in RGB form is converted in to L*a*b* color model. This converted image is given to the fuzzy C-means clustering algorithm. The result of this algorithm is given in Fig 6.

Fig. 4 Fuzzy C-means Clustering

Conclusion and Discussion:

This paper discusses various segmentation algorithms for gray level images and color images. Of the algorithms discussed K-means clustering and Fuzzy C-means

clustering algorithms are giving better segmentation output for the field image of the leaves obtained using digital camera. Other segmentation algorithms give either over segmentation or under segmentation of the image.

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