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Learning Towards Image Segmentation Framework Using Region Based Thresholding Techniques

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Abstract: This paper addresses Image Segmentation Techniques, their performances and efficiency with various gray level images. Image segmentation has been, and still is, a relevant research area in Computer Vision and Image Processing Applications. Computer Vision is a field of artificial intelligence used to program a computer to understand the features in an image; and Image Segmentation, is one of the goal to be achieved using computer vision. In Several Computer Vision Applications like Object Recognition, Robotics and Measurement etc., Image Segmentation techniques are used. If there are a number of targets in an image analysis system, image segmentation is necessary: locating and isolating the targets in an image and then identifying them. Once isolated, the targets can be measured and classified. A variety of image segmentation algorithms have been proposed in last 30 years. Most of the algorithms are specified and good for some particular type of applications, but they are not suited for other applications, hence research and algorithms are in developing stage in this area to provide best results for all kind of applications. In this paper, we enumerate and reviews several popular image segmentation algorithms, specially Regions Based Image Segmentation, discuss their specialties.

Keywords: Image Processing; Image Segmentation; Image Histogram; Threshold.

I. INTRODUCTION

The goal of Image Segmentation Techniques is to change the characteristics of image into more meaningful ones, thus facilitating analysis and categorization. Image segmentation is an important and common technique for a variety of image processing tasks, It is a part of Digital Image Processing [1][2]. Usually image segmentation is an initial and vital step in a series of processes aimed at overall image understanding. Image segmentation is a necessary steps in any image processing task which involving the labeling and identification of constituents parts of an image or picture/scene. It may be describe as a process of subdivides an image in to its constituent parts and extracts the parts or objects which are of interest. In Image, the object is everything what is of interest in the image (from the particular application point of view). The rest of the image is background. In other words, Image Segmentation is partitioning an image into multiple regions or sets of pixels [3][4][5]. The result of image segmentation is a set of segments that collectively cover the entire image. For example it may be of interest to identify the number of items of a given color, size, or shape in an image. The simplest form of image segmentation splits the image in to two parts, the Object and other is background, based on the amplitude value of a pixel. Similarly, it may be of interest to apply an image processing operator to a sub-region with specific characteristics. A dense literature is available for image segmentation technique [6] [7] [8]. But, at present there is no general method or algorithm for image segmentation technique.

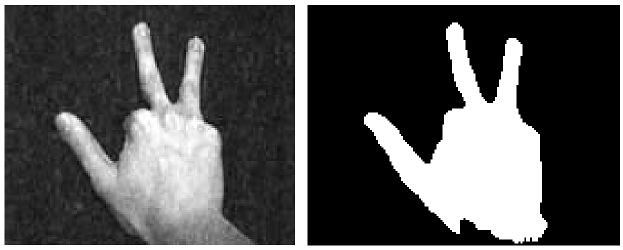
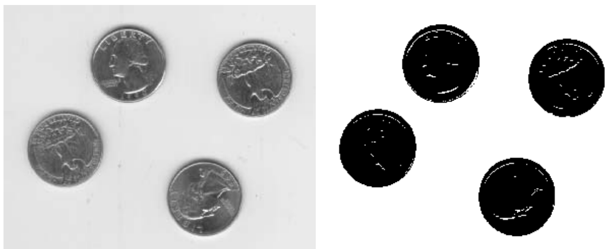
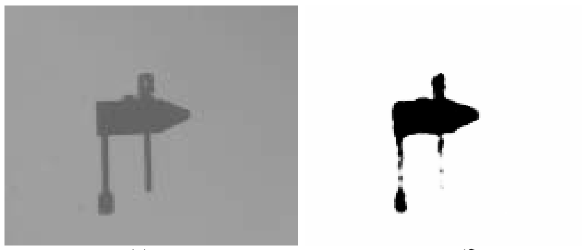


Figure. 1 (a) (b)



(c) (d)



(e) (f)

Figure. 1 (a),(c),(e) represents the Original image and (b),(d),(f) represents the Image After Segmentation.

In view of Gonzalez & Woods, Image Segmentation algorithms are based on the following image gray level properties:

A. *Discontinuity*

The objective is to find hard changes on gray level, using this information as the method to edge detection; i.e., to partition the image based on abrupt changes in intensity (grey-levels) e.g. edges.

B. *Similarity*

Closest pixels are very similar, i.e. to partition the image into similar (according to predefined criteria) regions.

A Mathematical definition of Image Segmentation proposed by Fu & Mui [9] may be given as: Let R represent the entire spatial region occupied by an image. Image segmentation is a process that partitions R into *n* sub-regions, R1, R2, …, Rn, such that :

$$\bigcup_{i=1}^{n} R_i = R \qquad (1)$$

$$For\ all\ i\ and\ j, i \neq j, there\ exist\ R_i \cap R_j = \varnothing \qquad (2)$$

$$For\ i = 1,2,......n,\ it\ must\ have\ P(R_j) = TRUE \qquad (3)$$

$$For\ all\ i \neq j, there\ exists\ P(R_i \cup R_j) = FALSE \qquad (4)$$

$$For\ \ all\ i = 1,2,......n,\ R_i\ is\ a\ connected\ component. \qquad (5)$$

Where:

P(R) is a uniformity predicate for all elements in set R and Ø represents an empty set. The above equations have some significant description, Equation (1) represents that the union of segmented regions could include all pixels in an image., Equation (2) represents that the different segmented regions could not overlap each other, Equation (3) represents that the pixels in the same regions should have some similar properties, equation (4) represents that the pixels belonging to different regions should have some different properties and finally Equation (5) represents that the pixel in the same region resulted from segmentation are connected. There are various issues which are related to image segmentation that require detailed discussion and knowledge. The general problem encountered in image segmentation is to choose a specific algorithm for isolating the objects from the background. Now the problem is what should be a good image segmentation? So the Regions of image segmentation should be uniform and homogeneous with respect to some characteristics or property, such as gray tone or texture. Interior Region should be simple and should be without any holes, Adjacent Regions of image segmentation should have significant different values with respect to some characteristics and should be uniform, the boundary of image segmentation should be simple, accurate and should not be ragged. Image Segmentation is also associated with Pattern Recognition Problems and referred as Object Isolation:

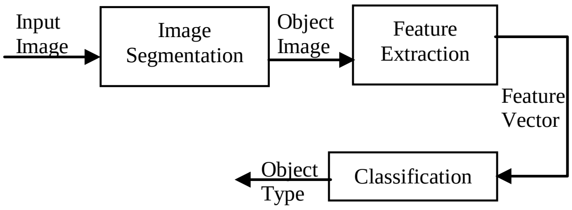


Figure. 2

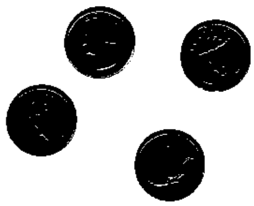
The practical result does not perform well if the gray levels of the different objects in image are somewhat similar. For that, another image processing techniques called image enhancement is used to highlight the significant features of the original image and the task of image segmentation becomes easy. Some of the other issues of the image segmentation are to choose good algorithm for image segmentation, measuring their performance, and considerate their impact on the image analysis system.

The paper is organized as follows. Section II describes the various Image Segmentation Techniques and focusing the detailed description and comparison by showing graphical results. Section III presents the Conclusion.

II. IMAGE SEGMENTATION TECHNIQUES

Image segmentation techniques has been approached on the basis of number of perspectives [10][11], they are mainly Gray level-Histogram Based Image Segmentation Technique, Threshold Based Image Segmentation Technique, Edge Based Image Segmentation Technique, Graph Based Image Segmentation Technique, Watershed Based Approach etc. for Image Segmentation. On the basis of pixels property, there are two main approaches of Image segmentations they are, Similarity Based Image Segmentation (or Regions Based) and Discontinuity Based Image Segmentation (or Edge Based). Now what are Regions and what are Edges? Edges are based on the differences between values of the adjacent pixels, On the other hand, Regions are based on the Similarities between values of the adjacent pixels. Regions are bounded by the closed contours. To obtain Regions, we fill the closed contours and to obtain the Edges, we trace out the regions.

Fig. 3(a) (b)



(c)

Figure. 3 (a) represents the Original image, (b) represents Edges and (c) represents Regions

Similarity based Image segmentation means a group of the pixels which are similar in some sense. Overall Image Segmentation Techniques [12] may be summarize with the help of table i.e. Table I.

In Region Based mage Segmentation [13] [14], we use uniformity criteria which are calculated in regions of image domain. In this segmentation, two criteria are specified, In one criteria, Image in divided into different Regions that are similar on the basis of gray character, Texture Character etc. like ‘Region Growing Technique’ and ‘Region Splitting & Merging Technique’, and in other type of criteria, Object may be extracted from the background by selecting a reasonable threshold value, like ‘Thresholding Technique based Image Segmentation [15]' i.e., Otsu and Optimal Thresholding etc. The main principle behind Thresholding Technique is based on the characteristics of the images [16]. Graphically Thresholding Process may be represented as:

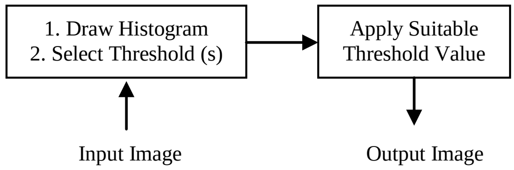


Fig. 4

$$if\ a[m,n] \ge \phi$$

$$a[m,n] = object = 1 \qquad (1)$$

$$else$$

$$a[m,n] = background = 0 \qquad (2)$$

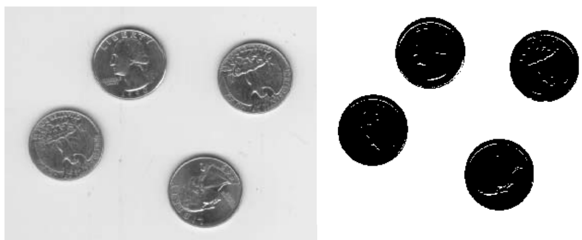
In general, there is no universal method to select threshold that work on all type of image, but there are two alternative procedures that can applied to choose the threshold; they are Fixed Thresholding and Adaptive Thresholding. In Fixed Thresholding, Thresholding inviolves analysis of histograms, when the gray level histogram of the image groups separates the pixels of the objects and the background into two modes, hence threshold

Table I: Image Segmentation Classification

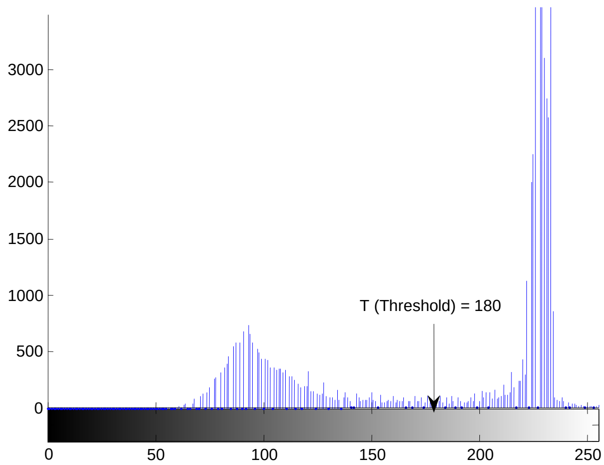
Sl. No.	Main Category	Sub Category	Sub-Category Details			Interpretation
I	Pixel Discontinuity Based Image Segmentation Techniques	Edge Based Image Segmentation	(i)	Gray Based Histogram Technique		Based on the division of the Image by detecting the Edges among different Regions
			(ii)	Gradient Based Technique	(a) Differential Coefficient Techniques	
					(b) Canny Edge Detector Based Techniques	
II	Pixel Similarity based Image Segmentation Techniques	Region Based Image Segmentation	(i)	Thresholding Technique	(a) Otsu	In this technique, Object may be extracted from the background by selecting a reasonable threshold value.
					(b) Optimal Thresholding	
					…….	
			(ii)	Region-Operating Technique	(a) Region-Growing	In this Technique, Divide the Image into different Regions that are similar, homogeneous or uniform on the basis of some predetermined property e.g. gray character, Texture Character etc.
					(b) Region Splitting & Merging	
III	Special Theory Based Image Segmentation Techniques or Hybrid Approaches		(i)	Neural Network Based Image Segmentation		In this technique, Image Segmentation is Based On the Learning Technique
			(ii)	Fuzzy Clustering Based Image Segmentation		In this technique, Image Segmentation is Based On the Fuzzy Set Theory
			(iii)	Physical Characteristics Based Image Segmentation		In this technique, Image segmentation is done on the basis of some physical characteristics

Thresholding is very useful to separate out the regions of the image corresponding to objects in which we are interested, from the regions of the image that correspond to background. Thresholding is very old, straightforward and popular technique for Image Segmentation. The thresholding often provides an easy and convenient way to perform the segmentation on the basis of the different intensities or colors in the background and foreground regions of an image.The output of a binary image representing the segmentation, black pixel corresponds to background and white pixel corresponds to foreground (or vice versa). In simple implementations, the segmentation is determined by a single parameter known as the intensity threshold Ø. In a single pass, each pixel with a gray value 'a' in the image is compared with this threshold Ø. If the pixel intensity is higher than the threshold, the pixel is set to, say, white ='1' in the output and if it is less than the threshold, it is set to black ='0'. We can say that,

'T' can be easily choosen in between the modes. For a light object, in a dark background, any pixel for which f(x,y)>T, is labeled as an object point. Otherwise the pixel is labeled as a background point. Likewise, for a dark object on a light background, any pixel for which f(x,y)<T, is labeled as an object point, otherwise the pixel is labeled as background point. As we have shown in Fig. 4(a) the background is uniform or illumination is uniform and it's histogram clearly shows two peaks and one valley regions. So choose Threshold value in the valley region 'T'.



(a) (b)



(c)

Figure 5 (a) represents the Original image, (c) represents it's Histogram indicating Threshold value 'T'=180 and shows the well separation of object and background, threshold greater than 180 represents the objects while less than 180 represents background and,(b) Image After Segmentation.

Now what happens when there are so many peaks and valleys in an image histogram as given below

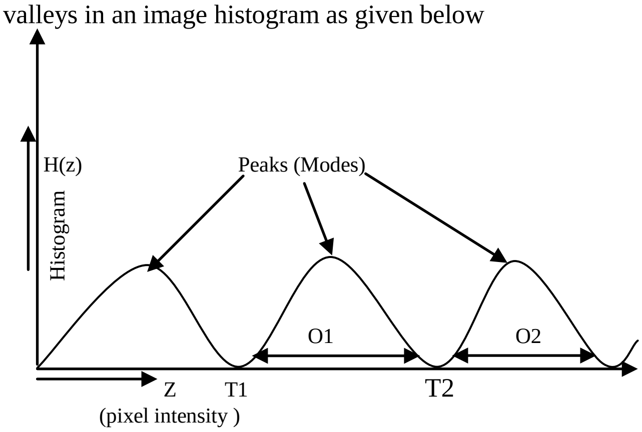


Fig. 6

Means if the histogram is multimodal as shown in above figure Fig. 5 (also see Fig. 6), in that histogram there are three different intensity regions, and are separated by three intensity bands, in that situation, decision rules is to choose threshold value T1 in first valley region and T2 in second valley region, in this conditions, Intensity value at location (x,y),

$$f\left(x,y\right) > T2 \text{ means pixel } \left(x,y\right) \in \textit{Object } \mathrm{O2}$$

$$T1 < f\left(x,y\right) \leq T2 \text{ means pixel } \left(x,y\right) \in \textit{Object } \mathrm{O1}$$

$$f\left(x,y\right) < T1 \text{ means pixel } \left(x,y\right) \in \textit{Background}$$

Therefore for selecting threshold, to test the image for segmentation, there should be some particular rules for Threshold which can be summarized as a in general, T is a combination function of :

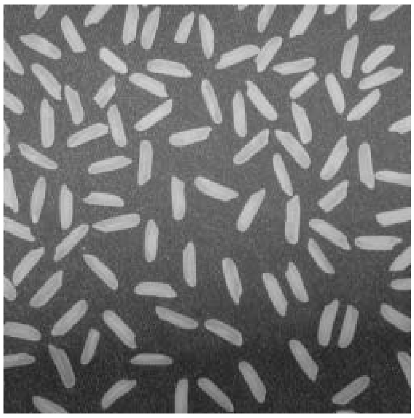
$$T = f\,(T[x, y, f\,(x, y), p(x, y)])$$

Where

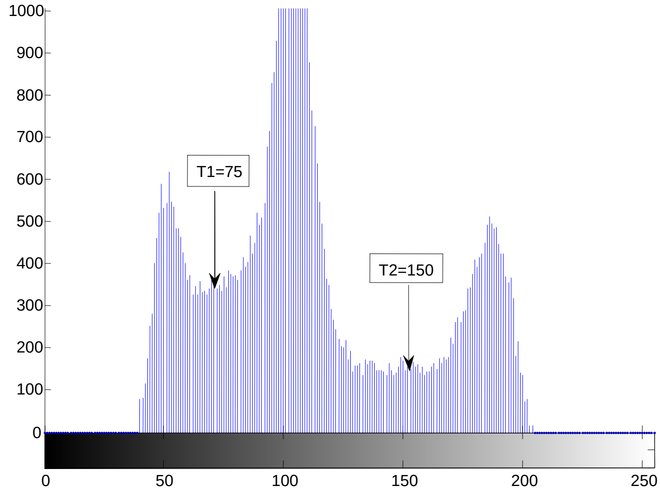
(x, y) *indicates pixel location in the image*

$f\,(x, y)$ *indicates pixel* in *tensity values at location* (x, y)

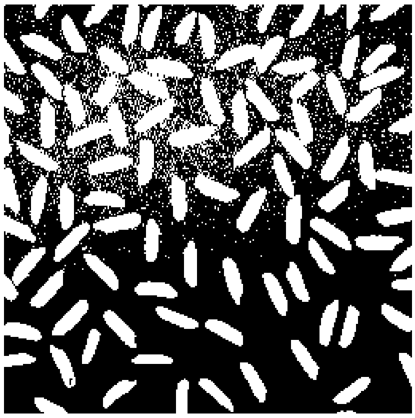
and $p(x, y)$ *indicates local property in a neighbourhood centered at* (x, y)



(a)



(b)



(c)

Figure. 7 (a) represents the Original image, (b) represents it's Histogram indicating with Three Peaks and Two Valley Regions choose Two Threshold value 'T1=75' and 'T2=150' (c) represents Segmented Image.

So, depending on above general threshold rules, we can define global threshold, local threshold and adaptive threshold or dynamic threshold in such a way:

$$(i)\ \textit{If } T = f(x,y), \textit{ then}$$
$$\textit{Threshold T is called as Global Threshold}$$
$$(ii)\ \textit{If } T = f[(x,y), p(x,y)], \textit{ then}$$
$$\textit{Threshold T is called as Local Threshold}$$
$$(iii)\ \textit{If } T = f[(x,y), p(x,y), (x,y)],$$
$$\textit{then Threshold T is called as Adaptive or Dynamic Threshold}$$

Let g(x,y) is thresholded image then,

$$g(x,y) \text{ (Thresholded image)} \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) <= T \end{cases}$$

T can be Global, Local or Adaptive Threshold, if we have bright object and dark background then output image or threshold image :

$$g(x,y) \text{ (Thresholdedimage)} \begin{cases} 1 \text{ if } f(x,y) > T \text{ is Object pixel} \\ 0 \text{ if } f(x,y) <= T \text{ is Background pixel} \end{cases}$$

Now if we are not able to see the histogram, means without histogram can we are able to determine the threshold? Yes we have a method to detecting automatic threshold value with the help of iteration process by the algorithm which can be defined as:

Step I : Choose initial value of Threshold T

Step II : By selecting threshold value we are making two groups of different type of pixels i.e. we are separating intensity values in two groups say Group G1 belongs to pixels of similar type and Group G2 belonging the pixels of similar type.

Step III : Compute the mean or average intensity values u1 belongs to G1, and u2 belongs to G2.

Step IV :Compute average Threshold value T=(u1+u2)/2.

Step V : Go to step II

Step VI : Repeat the process until we find Threshold at iteration I, Ti and Threshold at iteration i+1, Ti+1 in such a away that the variation | Ti – Ti+1 | <= T' (some pre-specified value).

When the background is uneven as a result of poor or nonuniform illumination conditions occurs it is very difficult to find out a single threshold that separate object from its background, therefore a fixed (or global) gray-level threshold will not segment the image correctly. In general this technique is less reliable than a single variable threshold, because it is often difficult to establish multiple threshold to effectively isolate the region of interest, especially when the number of modes in the corresponding histogram is high. One more difficulty comes when the modes of the histogram are not easily separate. Adaptive Thresholding is very useful to compensate for the effects of non-uniform illumination. When a different threshold (T1, T2, T3,….) is used for different regions in the image, It is called Adaptive Thresholding or Dynamic Thresholding [17],[18]. Now question is when is thresholding useful ? So it is useful when the peaks in the histogram are well separated, Low noise, large signal-to-noise ratio, the illumination over the image is close to uniform and the objects and the background are of similar sizes. Thresholding is simple, fast, computationally inexpensive and the oldest segmentation method and there is no requirement for regions to be continuous.

One of the problems with thresholding is that position information is lost in the counting process that generates the histogram. Although an attempt was made to use some positional information, there is no guarantee that the regions will be connected. Segmentation using Region Based Methods uses thresholding but also guarantees connected regions. For blurred and noisy images discontinuity based image segmentation technique is not able to produce good results and therefore we use Region Operating Technique i.e.

Region Growing' and 'Region Splitting and Merging Techniques'. Since it is an iterative technique so it takes more computation time to produce better results. In Region Operating Technique, the Image is divided into different Regions which are similar, homogeneous or uniform on the basis of some predetermined property e.g. Gray character, Texture Character etc. A Region Growing Technique use one or more pixels or a set of pixels which are known as seeds pixels and grows the region around seeds based upon some homogeneity criteria. If the adjoining pixels are similar to the seeds, they are merged with them with a single region The process remains continue till all the pixels in the image are assigned to one or more regions [19]. In other words, this technique assembles all the pixels into larger regions based on predefined seed pixels, growing criteria, and stop conditions. The disadvantage of Region Growing is that it depends heavily on the locations of the seed pixels. If correct a priori information is available about the locations of the seed pixels, Region Growing can produce very good results.

If the seed pixel locations are incorrect, the output suffers quite a bit. Region Splitting & Merging Image Segmentation Technique is based on theory of quad tree data [20]. In this technique, there is no need to select seed point, here image is divided into a set of arbitrary unconnected regions and then this region are merged and or splits on the basis of some reasonable image segmentation conditions. In other words simply divides the image into sub-regions of uniform size), then merge adjacent sub-regions whose intensity are close, and split a sub-region when its uniformity (such as measured by the standard deviation) is bad.

III. CONCLUSION

There are various techniques that perform Image Segmentation. Image Segmentation fields is a very large field and to get the best output more research is needed. This paper mainly explore various Image Segmentation Techniques specially 'Region Based Image Segmentation Thresholding Techniques with various examples'.

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