A Review on Image Segmentation Techniques

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Abstract— Image segmentation is one of the most essential segment in numerous image processing and computer vision tasks. It is a process which divides a given image into different regions and objects. It has now become a bloom field of research in computer vision. In this paper, the different techniques of image segmentation i.e. edge based segmentation, region based segmentation, thresholding based segmentation, clustering based segmentation, and also the diagrammatic difference between the all these four technique, are reviewed. There are many image segmentation techniques available, but there is no single technique suitable for all the applications due to the variation in quality of an image and the variability in shape of an image. Hence one has to choose the technique according to the requirement of the applications.

Keywords— Image Segmentation; Image; edge detection; Thresholding; Cluster; K-means;

I. INTRODUCTION

In today's world, images play a very crucial aspect for dispatching information. By figuring out images, the material derived from it can be used in various fields such as in medical purposes like detection of cell of cancers, locating objects in satellite images, Robotic, Diagnosis, Face Recognition etc. But to figure out the image, we need a suitable method to process and understand an image, these objectives are fulfilled by image segmentation [1].Image segmentation is a process of parting a digital image into number of segments (sets of pixel).The main purpose of image segmentation is that the value is appointed to every pixel of an image in such a way that pixels which shares the same characteristics (Color, intensity, texture) are assembled together. The reason behind image segmentation is to reduce the information for the easy scrutiny of the image for many purposes. Image segmentation helps to find the region of interest in an image.

An image is mostly a two-dimensional function f(x,y), where x and y are contiguous coordinates, and at a given coordinate ,the amplitude of this function gives the value of intensity of an image. When the intensity of f and the value of x, y are finite then the image is called digital image [2].

There are several image segmentation techniques available. However, it should be observed that there is no standard segmentation technique for a particular image. So, the choice of segmentation technique over another is resolved by distinct type of image and application being considered. Thus, the algorithm developed for a group of images may not apply to the images of another class [1] [5]. So, to make segmentation more corrective and effective, various techniques have been suggested in the literature.

II. SEGMENTATION TECHNIQUES

A. Edge Detection

In the edge detection technique, the pixels on the boundary are connected with each other to forms the edge between two regions that differ in the intensity value. It is used to find discontinuities in grey level images. Edges are the sign of absence of continuity. In an image, edge represents object boundaries and thus helps in detection and segmentation of objects in an image [5] [6].The four types of edges which helps to find the different shape of the image are given in the Figure 1.

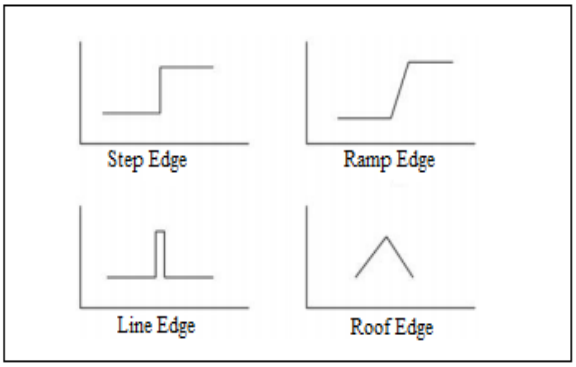

Fig. 1. Type of Edges

The necessary appearance of an image can be detected from the boundary of an image such as corners, lines, curves etc. Edge image is obtained without encountering any changes in physical qualities of the main image [3][4]. The areas where the edge detection is used are image processing in medical field, biometrics etc. There are different types of edge detection operators used in the detection of edges of an image and are organized into two groups as:

1) 1st order Derivative
   - Prewitt operator
   - Sobel operator
   - Canny operator
2) 2nd Order Derivative

- Laplacian operator
- Zero-crossings.

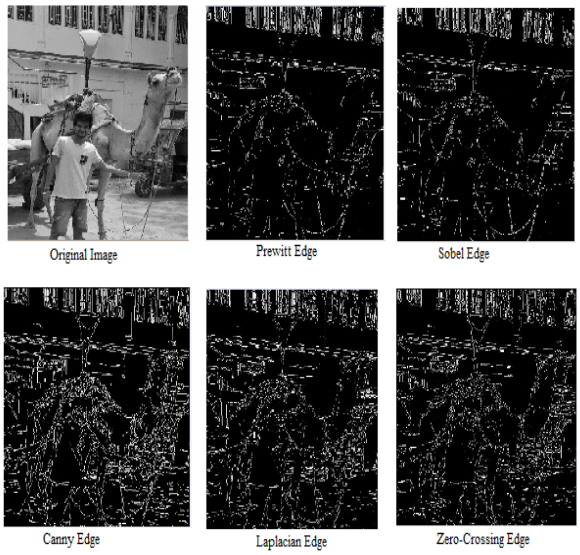

Fig.2. Using Edge Detection Methods

Figure 2 shows the comparison of six different operators used in edge detection of an image of a boy with a Camel, as the different operator work better in different conditions.

B. Region Based Methods

As in relation with edge detection method, segmentation algorithms based on region are relatively simple and more immune to noise [7][8]. Regions in an images are a group of undivided pixels with similar properties. Pixels of an object are associated together and marked. This method is basically based on continuity. It divide the full image into many groups, keeping in concern some rules such as all pixels in a region must have the same gray level tone. The following methods of region based segmentation based on region are as follow:

1) Region growing: Region growing [9] is a technique for extracting a region of the image that is connected, based on some predefined criteria. The criteria used, is to compare the properties of contestant pixel to its neighbors pixel ,to check whether they fall in the same class. In other words, the basic idea is to group a collection of pixels with similar properties to form a region [11].The gratification of this technique is that the connected regions are guaranteed. The general steps involved in region growing are:

a) Determine the seed in an image to start the process.

b) Determine the criteria or class to grow the region such as grey level intensity, color, texture, shape etc.

c) Grow the region by involving each pixel which fulfills the predefined similar criteria to the seed pixel.

d) Stop c) process when there is no availability of pixel that fulfills the criteria for including it in the region.

2) Region splitting and merging: In this Technique, images, according to the variation, are brake into different quadrant. And then these quadrants, merges until all the regions become uniform or until desired number of region have been established. This braking technique is based on theory on quad tree data. Quad tree is a tree in which each node has exactly four branches [11].It is a Top-down approach. The figure given below demonstrate the process:

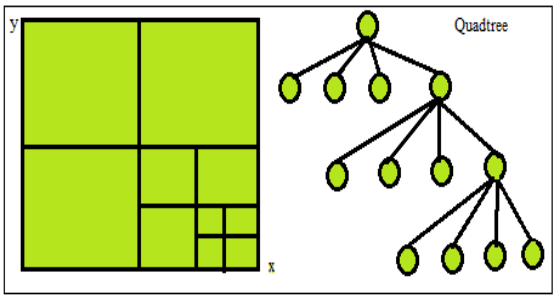

Fig.3. Quad Tree

The general steps involved in the region splitting and merging are:

Let R represents the full region of image and select Q as a predicate, then

a) Start with the full image if Q(R)=FALSE[12], we divide the image into quadrant, If Q is false for any sub quadrant then, subdivide the quadrant into another sub quadrant and repeat till no further splitting is possible or when Q is true.

b) Then, merge the regions R_j & R_k for which j=!k

Where j=1,2,3…n and,

k=1,2,3….n

c) Stop when no further merging of quadrant is possible.

C. Thresholding Technique

Thresholding technique is one of the most widely used techniques among all image segmentation technique. It is simple but powerful approach for segmenting the images having light objects on dark background [12]. Thresholding operation can transform a grayscale or color image into a binary image considering it as a binary region map i.e. it selects a suitable value of threshold T, to divide the pixels of an image into two possibly disjoint regions with the intention of separating the objects from background. The pixels with input data

values smaller than the threshold T contributes to the background and other pixels with input values, greater than or equal to T, contributes to the object. For input image f(i, j), The output threshold image g(i, j) can be define as:

$g(i, j) = 1$ for $f(i, j) \geq T$

$= 0$ for $f(i, j) < T$ (1)

In algorithm, we will choose a proper value T to divide the pixel into different classes and to separate the object from the background. As per the selection of thresholding value, two types of thresholding methods are in existence [13], i.e. Global and local thresholding.

1) Global Thresholding: In this approach, the threshold value T is constant and act as 'cutoff' value. This method is more suitable where the division of the intensity between the background and object is specific. So, only the single value can be used to differentiate both (object and background) apart. Some most common global thresholding methods are Otsu method, Entropy based thresholding, etc[11].

2) Local Thresholding: The Local Thresholding is also called as adaptive thresholding. In this, multiple thresholds are used to compensate for uneven illumination [14].The threshold varies from the image to image depending on the local characteristics of the different regions in the image. Some common used local thresholding techniques are simple statistical thresholding, 2-D entrophy-based thresholding histogram transformation thresholding etc[6].

It is crucial and complicated in making the choice between the above two thresholding approaches. The different method engaged in detecting the threshold value are-bimodal thresholding, pile thresholding, edge thresholding, optimal thresholding, multispectral thresholding.

Limitation of thresholding is that, thresholding does not take into account the spatial characteristics of an images due to this it is sensitive to noise[7], as both of these artifacts corrupt the histogram of the images, making separation more difficult.

D. Clustering Technique

Clustering is an unsupervised learning task, where one needs to identify a finite set of categories known as clusters to classify pixels [15].In this technique, we determine that the cluster in data that belong to specific region and are different from other regions. The identical norm is specified between the pixels and then identical pixels are club together in order to form a cluster. The identical norms specified can be shape, texture, color, size etc. The different type of clustering technique are k-mean clustering, c-mean clustering method. Among them the widely used method is k-mean clustering method.

1) K-mean Clustering: The K-mean algorithm is an repetitive technique which is used to divide an image into k groups or clusters, where k is a positive integer. The partition takes place according to the some similarity features like distance of pixel intensities and grey level intensity of pixels. The algorithm for this is:

a) Choose number of clusters k, randomly or based on some heuristic.

b) Assign each pixel to the cluster whose distance is minimum to center.

c) Re-compute the cluster center by calculating mean of all the values of pixel in a region.

d) Repeat steps 2 and 3 until Centroids does not move(i.e. no pixels change clusters)

e) Image is separated into K clusters.

The advantage of this algorithm is that it decreases the total distance between the pixel and cluster center, of the cluster they are assigned to .This algorithm is simple with low cost due to which it run fluently on large image. The disadvantage is that we have to set the desired number of cluster before. And the output produced each time by this algorithm is not the same as expected.

2) C-mean Clustering: The C-mean algorithm is a method in which one piece of data can be simultaneously a member of two or more clusters. It is also known as soft K-means clustering method. In this method the centroid of a cluster is the mean of all points. After each iteration, memberships and cluster centers are updated according to formulae given below:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} \mu_{ij}^{m} \left\| x_i - c_j \right\|^2, 1 \leq m < \infty$$

(2)

Where m = real number > 1,

N =number of data,

C =number of clusters; $2 \leq c < n$,

μ_{ij}=degree of membership of x_i in the cluster j,

x_i = d-dimensional measured data,

c_j=d-dimension center of the cluster,

The advantage of c-mean algorithm is that it gives the best result for the overlapped data set and is likely better then the k-means algorithm. There also exists the combination of the k-means algorithm with the fuzzy c-means algorithm which is called as fuzzy k-c means algorithm. The comparison between k-c means and c-mean algorithm is given in [10].

III. COMPARATIVE ANALYSIS

The Comparison of different image segmentation technique i.e. Edge detection, Region based,

Thresholding and clustering based technique, are represented with the help of the table given below:

Segmentation Technique	Method Description	Advantages	Disadvantages
Edge Detection Technique	Based on the detection od discontinuity, normally tries to locate points with more or less abrupt changes in gray level	Edge detection technique is the way in which human perceives objects and works well for images having good contrast between	1)Does not work well with images in which the edges are ill-defined or there are too many edges; 2)It is not a trivial job to produce a closed curve
Region-Based Technique	Group Pixels into homogeneous regions.Including Region growing, Region splitting and merging .	Work best when the region homogenity criterion is easy to define. They are also more noise immune than edge detection approach	1)Are by nature sequential and quite expensive both in time and memory
Thresholding Technique	Divides the image into two region i.e. Object and the background.	It does not need a prior information of the image.And it has less computional complexity	1)Does not work well for an image without any obvious peaks or with broad and flat valleys.
Cluster-Based Technique	Cluster of objects that are somehow similar in characterstics. The Criterion for checking similarity is implementation dependent	Minimizes the total distance of pixel to cluster center ,of the cluster they are assigned to .It is simple and low cost.	1)We have to set the desired number of cluster before and it does not produce same output each time the algorithm is executed

IV. CONCLUSION

This paper mainly focuses on the different image segmentation technique. At the last by having a brief insight over all the segmentation technique, we may conclude that it depends upon the requirements of the application to which technique to choose. The various facts that we may conclude from this study are:

- The image segmentation is crucial aspect for dispatching information from the image to understand the image or for image processing.
- There is no general technique available for image segmentation. We have to choose the technique according to the application that we are processing.
- Using a single technique, it will not provide the advanced result.
- Segmentation techniques are divided according to the similarity and discontinuity of pixels of the image.

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REFERENCES

[1] Rajeshwar Dass, Priyanka, Swapna Devi, "Image Segmentation Techniques", in IJECT Vol. 3, Issue 1, Jan- Mar 2012.

[2] P. S. Liao, T.-S. Chen and P.-C. Chung, "A fast algorithm for multilevel thresholding," J. Inf. Sci. Eng., vol. 17, no. 5, pp. 713–727, Sep. 2001.

[3] Ibrahiem M. M. El Emary, "On the Application of Artificial Neural Networks in Analyzing and Classifying the Human Chromosomes", Journal of Computer Science, vol.2(1), 2006, pp.72-75.

[4] N. Senthilkumaran and R. Rajesh, "A Study on Edge Detection Methods for Image Segmentation", Proceedings of the International Conference on Mathematics and Computer Science (ICMCS-2009), 2009,Vol.I, pp.255-259.

[5] Edge Detection Techniques Evaluations and Comparisons. Ehsan Applied Mathematical Sciences, Vol. 2, 2008, no. 31, 1507 - 1520.

[6] Evaluating The Effectiveness Of Region Growing And Edge Detection Segmentation Algorithms.Ahmed R. Khalifa 2010.

[7] W. X. Kang, Q. Q. Yang, R. R. Liang,"The Comparative Research on Image Segmentation

Algorithms", IEEE Conference on ETCS, pp. 703-707, 2009

[8] H. Zhang, J. E. Fritts, S. A. Goldman, "Image Segmentation Evaluation: A Survey of unsupervised methods", computer vision and image understanding, pp. 260-280, 2008.

[9] D.L.pham, Ch. Xu and J.L.Princo, "A survey on current methods in medical image segmentation" Annual review of Biomedical Engineering, vol.2,2000.

[10] Ajala Funmilola A , Oke O.A, Adedeji T.O, Alade O.M, Adewusi E.A. "Fuzzy k-c-means Clustering Algorithm for Medical Image Segmentation" Journal of Information Engineering and Applications ISSN 2224-5782 Vol 2, No.6, 2012.

[11] Segmentation Techniques For Image Analysis IJAERS/Vol. I/ Issue II/January-March, 2012.

[12] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 2nd ed., Beijing: Publishing House of Electronics Industry, 2007.

[13] Y. Zhang, H. Qu, Y. Wang,"Adaptive Image Segmentation Based on Fast Thresholding and Image Merging", Artificial reality and Telexistence-Workshops, pp. 308-311, 1994.

[14] S. S. Varshney, N. Rajpal, R. Purwar,"Comparative Study of Image Segmentation Techniques and Object Matching using Segmentation", Proceeding of International Conference on Methods and Models in Computer Science, pp. 1-6, 2009.

[15] V. K. Dehariya, S. K. Shrivastava, R. C. Jain,"Clustering of Image Data Set Using K-Means and Fuzzy K-Means Algorithms", International conference on CICN, pp. 386- 391, 2010.