Image Segmentation Review: A Survey of Image Segmentation Techniques

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Abstract- Segmentation is a process that divides the images into its regions or objects that have similar features or characteristics. Segmentation has no single standard procedure and it is very difficult in non-trivial images. The summit to which segmentation is carried out depends on the problem specification. Segmentation algorithms are based on two properties of intensity values-discontinuity and similarity. First category is to partition an image based on the abrupt changes in the intensity and the second method is to partition the image into regions that are similar according to a set of predefined criteria. In this paper some of the methods for determining the discontinuity will be discussed and also other segmentation methods will be attempted. Three basic techniques for detecting the gray level discontinuities in a digital images points, lines and edges. The other segmentation technique is the thresholding. It is based on the fact that different types of functions can be classified by using a range functions applied to the intensity value of image pixels.

Index Terms- *Edge detection, Region growing, Segmentation, Thresholding, Watersheds.*

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I. INTRODUCTION

The goal of image segmentation is to gather pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Segmentation is a challenging field of image analysis. In particular, medical image segmentation has become very important with development of complex medical imaging modalities which are capable of producing a large quantity of high-resolution two-dimensional (2-D) and three-dimensional (3-D) images. The problem of image segmentation has been studied extensively and there are a large number of methods described in the literature [6].

The first step in image analysis is to segment the image. Segmentation subdivides an image into its ingredient parts or objects. The level to which this subdivision is carried depends on the problem being viewed. Sometime need to segment the object from the background to read the image correctly and identify the content of the image for this reason there are two techniques of segmentation, discontinuity detection technique and Similarly detection technique. In the first technique, one approach is to partition an image based on abrupt changes in gray-level image. The second technique is based on the threshold and region growing. This paper discusses the first techniques using Edge Detection method.

Some examples of image segmentation are

- In automated inspection of electronic assemblies, presence or absence of specific objects can be determined by analyzing images.
- Analyzing aerial photos to classify terrain into forests, water bodies etc.
- Analyzing MRI and X-ray images in medicine for classify the body organs.

II. VARIOUS SEGMENTATION TECHNIQUES

A. Segmentation using discontinuities

Several techniques for detecting the three basic gray level discontinuities in a digital image are points, lines and edges. The most common mode to look for discontinuities is by spatial filtering methods.

Point detection idea is to segregate a point which has gray level notably different from its background.

 ISSN: 2321-8169
2584 – 2589

w1	w2	w3
w4	w5	w6
w7	w8	w9

Figure 1: Point detection mask

w1=w2=w3=w4=w6=w7=w8=w9 =-1, w5 = 8.

Response is R = w1z1+w2z2……+w9z9, where z is the gray level of the pixel.

Based on the response calculated from the above equation we can find out the points desired.

B. Line detection

Line detection is next level of complexity to point detection and the lines could be vertical, horizontal or at +/- 45 degree angle. Responses are calculated for each of the mask above and based on the value we can perceive if the lines and their orientation.

C. Edge detection

The edge is a regarded as the boundary between two objects (two dissimilar regions) or conceivably a boundary between light and shadow falling on a single surface. To find the differences in pixel values between regions can be compute by consider gradients. The edges of an image hold much information in that image. The edges tell where objects are, their shape and size, and something about their texture. An edge is where the intensity of an image moves from a low value to a high value or vice versa. There are numerous applications for edge detection, which is often used for various special effects. Digital artists use it to create dazzling image outlines. The output of an edge detector can be added back to an original image to enhance the edges. Edge detection is often the first step in image segmentation. Image segmentation, a field of image analysis, is used to group pixels into regions to determine an image's composition. A common example of image segmentation is the "magic wand" tool in photo editing software. This tool allows the user to select a pixel in an image. The software then draws a border around the pixels of similar value. The user may select a pixel in a sky region and the magic wand would draw a border around the complete sky region in the image. The user may then edit the color of the sky without worrying about altering the color of the mountains or whatever else may be in the image. Edge detection is also used in image registration. Image registration aligns two images that may have been acquired at detach times or from different sensors.

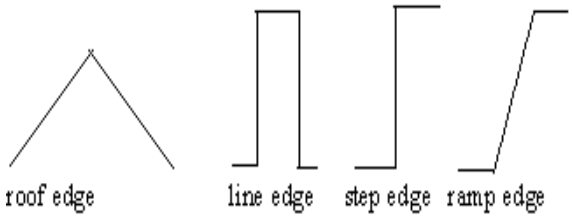

Figure 2 Different edge profiles.

There are an infinite number of edge orientations, widths and shapes (Figure 2). Some edges are straight while others are curved with varying radii. There are many edge detection techniques to go with all these edges, each having its own strengths. Some edge detectors may work well in one application and perform poorly in others. Sometimes it takes experimentation to determine what the best edge detection technique for an application is.

The simplest and quickest edge detectors determine the maximum value from a series of pixel subtractions. The homogeneity operator subtracts each 8 surrounding pixels from the center pixel of a 3 x 3 window. The yield of the operator is the maximum of the absolute value of each difference. Similar to the homogeneity operator is the difference edge detector. It operates more quickly because it requires four subtractions per pixel as opposed to the eight desired by the homogeneity operator. The subtractions are upper left – lower right, middle left – middle right, lower left – upper right, and top middle – bottom middle.

D. Segmentation using Thresholding

Thresholding is based on the hypothesis that the histogram is has two dominant modes, like for example light objects and an dark background. The method to extract the objects will be to select a threshold F(x,y)= T such that it separates the two modes. Depending on the kind of problem to be solved we could also have multilevel thresholding [8].

 ISSN: 2321-8169
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Based on the region of thresholding we could have global thresholding and local thresholding. Where global thresholding is considered as a function for the entire image and local thresholding involves only a certain region. In addition to the above mentioned techniques that if the thresholding function T depends on the spatial coordinates then it is known as the dynamic or adaptive thresholding. Let us consider a simple example to explain thresholding.

E. Basic global thresholding technique

In this technique the entire image is scanned by pixel after pixel and hey is labeled as object or the background, depending on whether the gray level is greater or lesser than the thresholding function T. The triumph depends on how well the histogram is constructed. It is very successful in controlled environments, and finds its applications primarily in the industrial inspection area. The algorithm for global thresholding [24] can be summarized in a few steps.

1) Select an initial estimate for T.

2) Segment the image using T. This will produce two groups of pixels. G1 consisting of all pixels with gray level values >T and G2 consisting of pixels with values <=T.

3) Compute the average gray level values mean1 and mean2 for the pixels in regions G1 and G2.

4) Compute a new threshold value T= (1/2) (mean1 +mean2).

5) Repeat steps 2 through 4 until difference in T in successive iterations is smaller than a predefined parameter T0.

F. Basic adaptive thresholding technique

Images having uneven illumination make it difficult to segment using the histogram. In this case we have to divide the image in many sub images [23] and then come up with different threshold to segment each sub image. The key issues are how to divide the image into sub images and utilize a different threshold to segment each sub image.

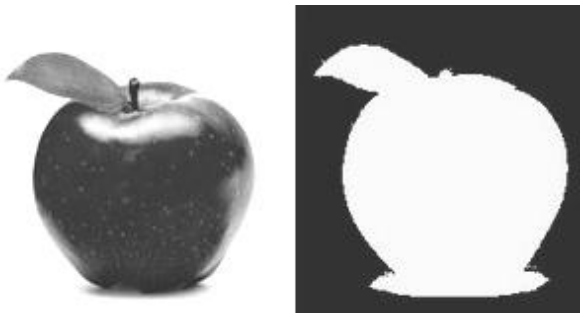

Figure 3: Thresholding segmentation [21]

G. *Region based segmentation*

We have seen two techniques so far. One is dealing with the gray level value and other with the thresholds. In this section we will concentrate on regions of the image.

Formulation of the regions:

An entire image is divided into sub regions and they must be in accordance to some rules such as

- Union of sub regions is the region
- All are connected in some predefined sense.
- No to be same, disjoint
- Properties must be satisfied by the pixels in a segmented region P (Ri) =true if all pixels have same gray level.
- Two sub regions should have different sense of predicate.

H. Segmentation by region splitting and merging

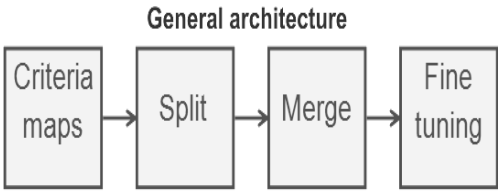

Figure 4: General architecture

The basic idea of splitting is, as the name implies, to break the image into many disjoint regions which are coherent within themselves. Take into consideration the entire image and then group the pixels in a region if they satisfy some kind of similarity constraint. This is like a divide and conquers method. Merging [10] is a process used when after the split the adjacent regions merge if necessary. Algorithms of this nature are called split and merge algorithms, consider the example of the split and merge process.

I. Segmentation by region growing

 ISSN: 2321-8169
2584 – 2589

Region growing approach is the opposite of split and merges.

- An initial set of small area are iteratively merged based on similarity of constraints.
- Start by choosing an arbitrary pixel [25] and compared with the neighboring pixel.
- 3. Region is grown from the seed pixel by adding in neighboring pixels that are similar, increasing the size of the region.
- 4 When the growth of one region stops we simply choose another seed pixel which does not yet belong to any region and start again.
- 5 This whole process is continued until all pixels belong to some region.
- 6 A bottom up method.

J. Segmentation by Morphological watersheds

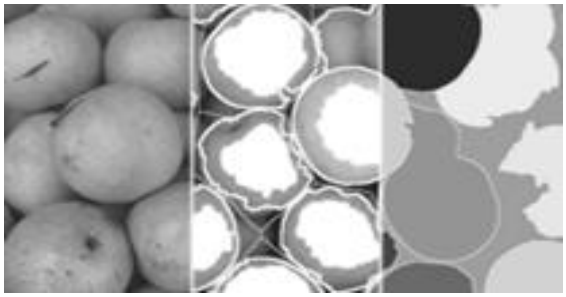

Figure 5: Segmentation by morphological watersheds [22]

This method combines the positive aspects of many of the methods discussed earlier. The basic idea to embody the objects in "watersheds" [20] and the objects are segmented. Below only the basics of this method is illustrated without going into superior details. The concept of watersheds is the idea of visualizing an image in 3D, 2 spatial versus gray levels. All points in such a topology are either belonging to regional minimum. All with assured to a single minimum, equal to two points where more than one minimum. A particular region is called watershed if it is a region minimum satisfying certain conditions.

K. Fuzzy Theory Based Image Segmentation

Fuzzy set theory is used in order to analyze images, and provide accurate information from any image. Fuzzification function can be used to remove noise from image as well [15]. A gray-scale image can be easily transformed into a fuzzy image by using a fuzzification function. Different morphological operations can be combined with fuzzy method to get better results [18]. Fuzzy k-Means and Fuzzy C-means (FCM) are widely used methods in image processing [10]. In this section several new approaches of image segmentation using Fuzzy theory is presented. Gour Chandra Karmakar [4] introduced a new fuzzy rule based image segmentation technique which can integrate the spatial relationship of the pixels. Three types of membership functions are used, i.e., Membership function for Region pixel distribution, to measure the closeness of the region, and to find the spatial relationship among pixels. There is no need to define parameters in their technique, like FCM algorithm. Fuzzy rules uses above three membership functions and then performs segmentation of an image. FCM and proposed technique is implemented on Matlab X-ray images. Results have shown that GFRIS outperform FCM and isolate the object from background accurately.

L. ANN Based Image Segmentation

In Artificial Neural Network, every neuron is corresponding to the pixel of an image. Image is mapped to the neural network. Image in the form of neural network is trained using training samples, and then connection between neurons, i.e., pixels is found. Then the new images are segmented from the trained image [12]. Some of the mostly used neural networks for image segmentation are Hopfield, BPNN, FFNN, MLFF, MLP, SOM, and PCNN. Segmentation of image using neural network is perform in two steps, i.e., pixel classification and edge detection [18]. In this section several new approaches of ANN used for image segmentation is discussed from last five years. Xuejie Zhang [11] proposed a new Fast learning Artificial Neural Network (FLANN) based color image segmentation approach for R-G-B-S-V (i.e., RGB and HSV) cluster space. In first step, noise is removed using 3*3 averaging filter to reduce the disparity in color distribution. In second step, pixels are converted to RGBSV space using HSV conversions. FLANN clustering is performed to produce a

cluster result of image. Next, pixels with same color are being separated. Segment number is assigned to each segment of image. Effect of tolerance and neighborhood size is observed. Results have shown that proposed algorithm produced perfect segments for colors in the image. Farhad Mohamad Kazemi [19] proposed a fast C-means based training of Fuzzy Hopfield Neural network

[17] in order to apply it into image segmentation. Objective function is used based on 2-f Fuzzy HNN. This objective function found the average distance between image pixels and cluster's centroids. According to author, Fuzzy HNN provides better segmentation as compare to other methods. Firstly, they make clusters from given data, then perform normalization, i.e. grey level images, calculate centroids, then compute distances, find new centroids, and computer new membership function value using fuzzy C-means [14]. The results have shown that FHNN provides a faster speed as compare to other techniques of ANN.

M. PDE Based Image Segmentation

PDE (Partial Differential Equations) equations or PDE models are used widely in image processing, and specifically in image segmentation. They uses active contour model for segmentation purpose. Active Contour model or Snakes transform the segmentation problem into PDE. Some famous methods of PDE used for image segmentation are Snakes, Level-Set, and Mumford shah method [9]. In this section, several new approaches for image segmentation based on PDE are discussed. In [9] presents a new method of segmentation of anatomical structure in medical images. Adaptive PDE models, i.e., fuzzy PDE Contour model, and PDE geometrical Contour model with Fuzzy C-Means classification is used for segmentation of images. Adaptive PDE models helped to find the region of interest. 3D brain MRI Image is used as a dataset. Fuzzy PDE model has segment the MRI brain image using Fuzzy Clustering approach. The model has outperformed 'Snakes' model and reduce some of drawbacks of Snakes model.

III. CONCLUSION

In this paper, the comparative studies applied by using various techniques of image segment. The study also reviews the research on various research methodologies applied for image segmentation. This study aims to provide a simple guide to the researcher for those carried out their research study in the image segmentation. Recent research in image segmentation techniques is presented in this paper.

References

[1] Haralick R. H, Shapiro L. G., Computer and Robot Vision, Vol. I, Addison–Wesley Publishing Company, 1993.

[2] A. D. Brink, "Minimum spatial entropy threshold selection," *IEEE Proc.Vis. Image Signal Process*, vol. 142, no. 3, pp. 128–132, 1995.

[3] W. Ma, B.S. Manjunath, "Edge Flow: a technique for boundary detection and image segmentation," *Trans. Image Proc.*, pp. 1375-88, Aug. 2000.

[4] G. C. Karmakar and L. Dooley, "A generic fuzzy rule based technique for image segmentation," *in Proc. IEEE International Conference on Acoustics*, Speech, and Signal Processing, Proceedings, 2001, pp. 1577-1580.

[5] Rafael Gonzalez and Richard E.Woods, "Digital Image Processing", 2Ed, 2002.

[6] B. Sumengen, B. S. Manjunath, C. Kenney, "Image Segmentation using Curve Evolution and Flow Fields," *Proceedings of IEEE International Conference on Image Processing (ICIP)*, Rochester, NY, USA, September 2002.

[7] Venugopal, "Image segmentation" written reports 2003.

[8] Jin Wang, "Image segmentation Using curve evolution and flow fields", written reports 2003.

[9] S. Bueno, A. M. Albala, and P. Cosfas, "Fuzziness and PDE based models for the segmentation of medical image," in *Proc. Nuclear Science Symposium Conference Record, IEEE, 2004*, pp. 3777-3780.

[10] D. Hu and X. Tian, "A multi-directions algorithm for edge detection based on fuzzy mathematical morphology," *in Proc. 16th International Conference on Artificial Reality and Telexistence--Workshops*, 2006, pp. 361-364.

[11] X. Zhang and A. L. P. Tay, "Fast learning artificial neural network (FLANN) based color image segmentation in

RGBSV cluster space," *in Proc. International Joint Conference on Neural Networks*, 2007, pp. 563-568.

[12] D. Suganthi and Dr. S. Purushothaman, "MRI segmentation using echo state neural network," *International Journal of Image Processing*, vol. 2, no. 1, 2008.

[13] F. M. Kazemi, M. R. Akbarzadeh, T. S. Rahati, and H. Rajabi, "Fast image segmentation using C-means based Fuzzy Hopfield neural network," *in Proc. Canadian Conference on Electrical and Computer Engineering*, 2008, pp. 001855-001860.

[14] X. Jiang, R. Zhang, and S. Nie, "Image segmentation based on PDEs model: A survey", *in Proc. 3rd International Conference on Bioinformatics and Biomedical Engineering*, 2009, pp. 1-4.

[15] S. Naz, H. Majeed, and H. Irshad, "Image segmentation using fuzzy clustering: A survey," *in Proc. 6th International Conference on Emerging Technologies*, 2010, pp. 181-186.

[16] D. Chaudhuri and A. Agrawal, "Split-and-merge Procedure for Image Segmentation using Bimodality Detection Approach", *Defence Science Journal*, Vol. 60, No. 3, May 2010, pp. 290-301Ó 2010, DESIDOC.

[17] W. Haider, M. Sharif, and M. Raza, "Achieving accuracy in earlystage tumor identification systems based on image segmentation and 3D structure analysis," *Computer Engineering and Intelligent Systems*, vol. 2, pp. 96-102, 2011.

[18] Irum, M. Raza, and M. Sharif, "Morphological techniques formedical images: A review," *Research Journal of Applied Sciences*, vol. 4, 2012.

[19] M. Yasmin, M. Sharif, and S. Mohsin, " Neural networks in medical imaging applications: A survey," *World Applied Sciences Journal*, vol. 22, pp. 85-96, 2013.

[20] Alan P. Mangan, Ross T. Whitaker, "Surface Segmentation Using Morphological Watersheds."

[21] Available threshold online "[**http://docs.opencv.org/doc/tutorials/imgproc/ /threshold.html]"**

[22] www.mathworks.in /image/description5.html

[23] Ioannis M. Stephanakis and George C. Anastassopoulos, "segmentation using adaptive thresholding of the image histogram according to the incremental rates of the segment likelihood functions".

[24] R. C. Gonzalez, R.E. Woods, "Digital Image Processing," *Publishing House of Electronics Industry, Beijing*, 3rd ed. pp. 711, 760-764.

[25] Thanos Athanasiadis, Yannis Avrithis and Stefanos Kollias, "A Semantic Region Growing Approach in Image Segmentation and Annotation".

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