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A Survey on Spatial Based Image Segmentation Techniques

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ABSTRACT: Image segmentation plays a vital role in image analysis, image understanding and image processing. It is used to determine actually what is inside the image. Image segmentation basically convert complex image into simple image so that image is more meaningful and easier to analyze. Image segmentation divides an image into its constituent regions or objects such that regions are homogeneous with respect to certain features such as color, texture, grey level and other features. In this paper, four categories which work in spatial domain are emphasized: Edge based, Region based, Thresholding based and clustering based segmentation.

KEYWORDS: Image segmentation; edge-based technique; Region based technique; Thresholding technique; clustering segmentation

I. INTRODUCTION

An image is considered to be a function of two real variables, for example, a (x, y) with a as the amplitude (eg. brightness) of the image at the real co-ordinate position(x, y) [1].An image can be considered to contain regions –of-interest or simply regions. The field of digital image processing refers to processing of images which are digital in nature by means of a digital computer[1].Digital image processing is needed to improve the quality of image by removing noise and other unwanted pixels and also to obtain more information on the image. Image segmentation is one of the most important step of image processing. Image segmentation is usually accustomed distinguish foreground from background [2].Image segmentation is typically used to locate edges and boundaries of the image. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of regions that are extracted from the image [5].

II. RELATED WORK

The paper [4], presents the overview of Edge detection technique, Thresholding method ,clustering method, Neural network technique, Fuzzy technique, Region based technique are explained and issues regarding to digital image processing used in various recognition patterns.

The paper [6], presents a comparative study of the basic image segmentation techniques i.e., Edge- Based, KMeans Clustering, Thresholding and Region-Based techniques.

The paper [11], tries to put light on the basic principles on the methods used to segment an image. This paper concentrates on the idea behind the basic methods used. Image segmentation can be broadly be categorized as semi-interactive approach and fully automatic approach and the algorithms developed lies in either of this approaches.

The paper [16], presents an evaluation of two popular segmentation algorithms, the mean shift-based segmentation algorithm and a graph based segmentation scheme. a hybrid variant that combines these algorithms. For each of these

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algorithms, three characteristics are examined that are correctness, Stability with respect to parameter choice, and Stability with respect to image choice.

The paper [17], represents two image segmentation techniques that could be used in the segmentation algorithm. Whenever we work with the image in any application, initial step is to segment the image in order to solve its complexity. The segmentation of images is the basic thing for understanding the images. It is used in the Image processing applications, Computer vision, etc. In this paper, two categories are emphasized: Edge based and region based segmentation, which further includes their respective techniques.

The paper [18], describes the different segmentation techniques used in the field of ultrasound and SAR Image Processing. Survey of current segmentation techniques is given in this paper and finally general tendencies in image segmentation are presented.

The paper [19], describes the various image segmentation techniques and discusses in detail the edge detection techniques and their evaluation. It gives an algorithm which is a combination of detection and evaluation of the edge detectors. The results show that the recognition rate depends on the type of the image and their ground truths.

In paper [20], in order to overcome the occurrence of noise during image acquisition, this paper presents a new clustering-based segmentation technique that may be able to find different applications in image segmentation. The proposed algorithm called Denoising-based (DB) clustering algorithm has three variations namely, Denoising-based-K-means (DB-KM), Denoising-based-Fuzzy C-means (DB-FCM), and Denoising-based-Moving K-means (DB-MKM). The proposed DB-clustering algorithms are able to minimize the effects of the Salt-and-Pepper noise during the segmentation process without degrading the fine details of the images.

III. TECHNIQUES FOR IMAGE SEGMENTATION

Image segmentation methods are mainly categorized on the basis of similarity property and discontinuity property. Methods based on discontinuity property are called as boundary based methods and those based on similarity property are called Region based methods [6].Methods based on discontinuity uses edge detection to identify the boundary of a region .Region based methods partition an image into regions that are similar with respect to some predefined condition.

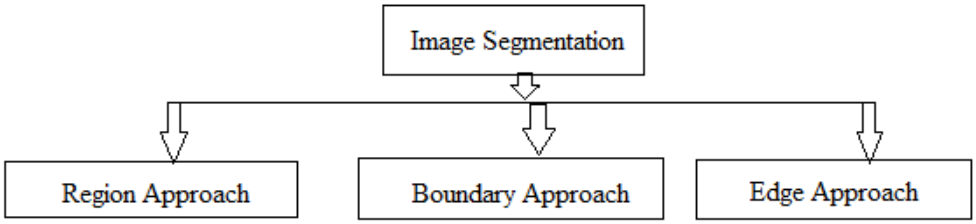

Figure 1. Image Segmentation Approach

Image segmentation techniques can be categorized as:

1) Edge Based method
2) Region Based method
3) Thresholding method
4) Clustering method

1) Edge Based method : Edge based method represents a large group of methods based on information about edges in the image. Edge- based segmentation depends on edges found in an image by edge detecting operators viz Roberts, prewitts, sobel etc. These edges mark image locations of discontinuities in gray level, color, texture, etc. Edge detection basically involves steps as below [15]:

1) Smoothing the image
2) Edge detection

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3) Edge localization

To remove the noise from the image to make it suitable for segmentation,a suitable smoothing filter is used. Then the possible edges are grouped together to check for candidature and finally the true edges are obtained by localizing the edge candidates. There are four different types of edges that may occur in the image

1) Step-edge
2) Ramp-edge
3) Ridge-edge and
4) Ramp-edge and are shown as below [14]:

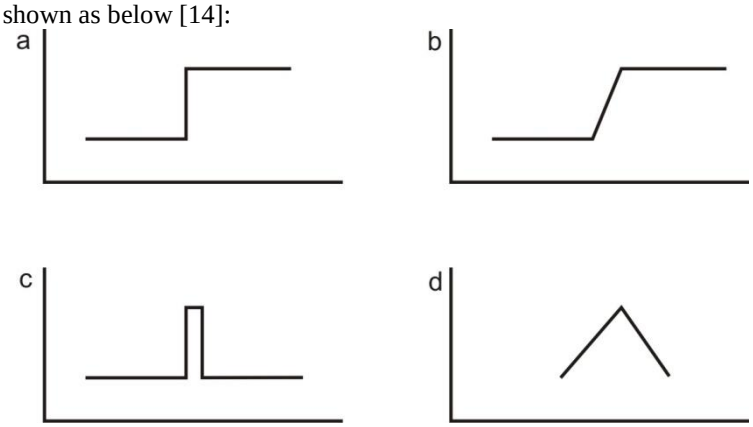

Figure 2. (a) Step-edge; (b) Ramp-edge; (c) Ridge-edge; (d) Ramp-edge

Edge detection operators can be broadly classified as: First order Derivative operators and second order derivative operators. First order derivative operators used gradient method to find the edges by using the maximum and minimum value of the gradient. The Laplacian operator is used with the second order derivative operator. The frequently used second order derivative operators are Laplacian of Gaussian operator and canny edge operator.

2) Region Based method: In region based method, segmentation is carried out based on the similarities in the given image. The region based approach to segmentation seeks to create regions directly by grouping together pixels which share common features into areas or regions of uniformity. The main objective of region based segmentation is to produce a homogeneous region which is bigger in size and results in very few regions in the image [11].

Region based segmentation can be carried out in two different ways:

a) Region growing

b) Region splitting and merging

a) Region growing: Region growing is a procedure in which pixels are grouped into lager regions based on some predefined condition. The main approach is to select a seed point and grow regions from this seed pixel. Seed point is a pixel from where we begin. Region growing can be processed in following steps:

i) Pick up an arbitrary pixel (x1, y1) from the image that needs to be segmented.This pixel is called seed pixel.

ii) Examine the nearest neighbours (4 or 8 neighbours depending on whether we assume 4-connectivity or 8-connectivity) of (x1, y1) one be one.

iii) The neighbouring pixel is accepted in the same region as (x1, y1) if they together satisfy the homogeneity property of a region i.e., if both of them satisfy the predefined condition.

iv) Once a new pixel (x2, y2) is accepted as a member of the current region, the neighbours of this new pixel are examined.

v) Repeat the process until no new pixel is accepted.

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Same process is repeated until all the pixels are assigned to some region or the other.

b) Region splitting and merging: This method is the most similar method to segment the image based on homogeneity criteria [13].The main objective of this method is to distinguish the homogeneity of the image and this method works on the basis of quad trees [11].The figure below shows the region splitting and merging method.

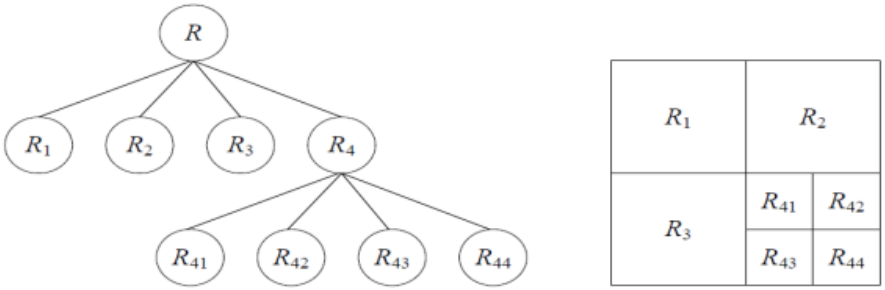

Figure 3. Region splitting and merging method

Algorithm for splitting and merging can be given as below:

Let R represent the entire image region and let P be any predicate.

If P(R) ==False

Divide the image into quadrants

If P if false for any subsquadrant

Subdivide that quadrant into subquadrant.

Stop dividing when P is true.

Merge the regions R_j & R_k ($j \neq k; j=1,2,3\ldots n, k=1,2,3..n$) if $P(R_j \cup R_k)$ == true.

3) Thresholding method: Thresholding is simple, fast and computationally inexpensive method of segmentation**.** This is the oldest but still most widely used method of segmentation [6]. Based on the value of threshold, there are two types of Thresholding methods, global Thresholding methods and local Thresholding methods.In both methods result depend on the value of threshold choosen. So selection of threshold value is very crucial.

Steps involved in performing global Thresholding:

1) Read the given image.
2) Plot the histogram of the given image.
3) Based on the histogram, choose the threshold T.
4) Using this value of T, segment the image into objects and background.

There are several methods adopted for selection of threshold value such as mean method,bimodal histogram, optimal Thresholding, multispectral Thresholding, edge maximization method[11].In global Thresholding, value of threshold(T) is same i.e. only one value of threshold is used and acts as a 'cutoff' value. However in local Thresholding, multiple values of thresholds are used. Selection of threshold value is done iteratively however; it is possible to derive automatic threshold selection algorithms. Limitation of single value Thresholding is that it works for bimodal images having bimodal histograms. Bimodal images are images whose histogram has two peaks. So threshold value is nothing but middle value of those two peaks. To handle situations where single value Thresholding will not work, is to divide an image into regions and threshold these regions individually.

Threshold value of different regions will depend on illumination of different regions and this method is reffered to as adaptive Thresholding. The algorithm for adaptive thresholding can be stated as:

1) Read the given image.

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2) Divide the image into subimage.
3) Choose a local threshold for subimage considered.
4) Compare the pixels in that subimage and segment the region.
5) Consider all subimages individually and choose corresponding threshold values.
6) Stop segmentation when all the subimages are processed.

Pros of threshold based methods :

1) Simple and fast.
2) Computationly expensive.

Cons of threshold based methods :

1) Sensitive to noise.
2) Selection of value of threshold is crucial and complicated and often lead to over or under segmentation.
3) May lead to missing edges [12].

4) Clustering method: Clustering or data grouping is a key post processing step in image processing. Clustering attempts to discover a set of groups such that samples within each group are more closely related to one another than the others assigned to different groups. The groups are called clusters. Clustering is an unsupervised method so no prior knowledge about data classes is needed. So clustering is a form of learning by observation, rather than learning by examples. Clustering is widely adopted in medical diagnostic studies, decision making, pattern analysis, data mining and image processing etc. [7]. In a pathological investigation,clustering is applied for the morphological study of cells or tissues. Clustering algorithm is also used for the compression of the real time streaming sequence with considerable information in multimedia applications such as news broadcasting, internet T.V., online lecture uploading and the wireless video communication [7].

The main purpose of clustering algorithm is to produce better segmentation. The quality of clustering result mainly depends on two factors, similarity measure used by the method and it's implementation [4].Similarity measure play an important role in the design of clustering method. A similarity criteria is defined between pixels [8], and then similar pixels are grouped together to form clusters. Pixels are grouped into clusters so as to maximize intra cluster similarity and minimize inter class similarity. Similarity may be defined by distance between two objects or connectivity based on density or contiguity [9].The quality of a cluster is also measured by its ability to discover some or all of the hidden patterns. Clustering methods are organized into the following categories: partitioning methods, hierarchical methods, density based methods and grid based methods. In partitional clustering, all the objects are partitioned so that there is no hierarchy present between the clusters. All the clusters are at the same level[9].Given a set of n objects, a partitioning method forms k partitions of the data, where each partition represents a cluster and k<=n. That is data is divided into k groups such that each group must contain atleast one object. Each cluster is represented by its centre. In hierarchical method, a hierarchy of clusters is formed.A hierarchical method can be either agglomerative or divisive. The agglomerative approach is also called bottom-up approach. The divisive approach is also called top-down approach. A tree structure called a dendrogram is commonly used to represent hierarchical clustering. Density based method starts with growing a given cluster as long as the density in the neighborhood exceeds some threshold. This method can filter out outliers or noise and can discover clusters of arbitrary shape.This method consider only exclusive cluster and not fuzzy clusters with overlapping regions. Grid-based methods form a grid structure consisting of finite number of cells. All the clustering operations are performed on the grid structure. The main advantage of this method is its fast processing time, typically independent of the number of data objects yet dependent on grid size [9].

IV. CONCLUSION

Edge-based segmentation methods work best on images in which the edges are easily detectable that is, images which have good local contrast. They do not work well with images in which the noise forms well-defined edges. Region-based schemes work well for images with an obvious homogeneity criteria (such as nearly equal gray level). Also, these schemes tend to be less sensitive to noise since homogeneity is typically determined statistically. Their disadvantages are that an initial split level must be chosen well else the technique could be very slow.Clustering based image segmentation involves clustering algorithms which can be used to obtain more faster and accurate segmentation result.

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