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SEGMENTATION TECHNIQUES FOR IMAGE ANALYSIS: A REVIEW

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Abstract— **As the premise of feature extraction and pattern recognition, image segmentation is one of the fundamental approaches of digital image processing, It is a pre processing step in many algorithms and practical vision system. In image segmentation, digital image divided into multiple set of pixels. There are many algorithms and methods available for image segmentation but still there needs to develop a unique method for it. In this paper, different image segmentation algorithms with its prospects are reviewed.**

Keywords— **Image segmentation, thresholding technique, edge detection, K-means**

I. INTRODUCTION

Images are considered as one of the most important medium of conveying information, in the field of computer vision, by understanding images the information extracted from them can be used for other tasks for example: navigation of robots, extracting malign tissues from body scans, detection of cancerous cells, identification of an airport from remote sensing data.[3]. Image segmentation is the foundation of object recognition and computer vision. In general, image noise should be eliminated through image preprocessing. And there is some specifically-given work (such as region extraction and image marking) to do after the main operation of image segmentation for the sake of getting better visual effect.[8]. The main goal of segmentation in the computer vision system is to simplify or change the representation of an image into something that is more meaningful and easier to analyze. Segmentation is mostly used to detect object, lines and curves in the image. More correctly, in segmentation value is assigned to every pixel in an image such that pixel with the same value share certain characteristics, such as colour, intensity or texture in a particular region.[12] More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image . Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Due to the importance of image segmentation a number of algorithms have been proposed but based on the image that is inputted the algorithm should be chosen to get the best results.[1] Some time image denoising is done before the segmentation to avoid from the false contour selection for segmentation to segment the image without loss of information for medical diagnosing purpose is a challenging job.[3] The remainder of this paper is organized as below; section II introduces the term image segmentation. Section III describes the current image segmentation techniques and section IV Concludes the overall study.

II. IMAGE SEGMENTATION

Image segmentation refers to the process of partitioning a digital image into multiple segments i.e. set of pixels, pixels in a region are similar according to some homogeneity criteria such as colour, intensity or texture, so as to locate and identify objects and boundaries in an image.[3] Image segmentation is generally defined as the basic image processing that subdivides a digital image $f(x, y)$ into its continuous, disconnect and nonempty subset $f_1, f_2, f_3, \ldots, f_n$, which provides convenience to extraction of attribute.[8]Practical application of image segmentation range from filtering of noisy images, medical applications (Locate tumors and other pathologies, Measure tissue volumes, Computer guided surgery, Diagnosis, Treatment planning, study of anatomical structure), Locate objects in satellite images (roads, forests, etc.), Face Recognition, Finger print Recognition, etc. [14][15]Many segmentation methods have been proposed in the literature. The choice of a segmentation technique over another and the level of segmentation are decided by the particular type of image and characteristics of the problem being considered.[3]

III. CURRENT SEGMENTATION TECHNIQUES

The Research on Image segmentation for many years has been a high degree of attention. Thousands of different segmentation techniques are present in the literature, but there is not a single method which can be considered good for different images, all methods are not equally good for a particular type of image. Thus, algorithm development for one class of image may not always be applied to other class of images. Hence, there are many challenging issues like

development of a unified approach to image segmentation which can be applied to all type of images, even the selection of an appropriate technique for a specific type of image is a difficult problem.[2][3]

Based on different technologies, image segmentation approaches are currently divided into following categories, based on two properties of image.

- **Detecting Discontinuities**

It means to partition an image based on abrupt changes in intensity, this includes image segmentation algorithms like edge detection.

- **Detecting Similarities**

It means to partition an image into regions that are similar according to a set of predefined criterion; this includes image segmentation algorithms like thresholding, region growing, region splitting and merging.[3]

CLASSIFICATION OF IMAGE SEGMENTATION METHODS

Main Categories	Sub Classes	
Edge Base segmentation	Grey Histogram Technique	
	Gradient Based	Differential coefficient technique
		Laplacian of a Gaussian
		Canny Technique
Region Based	Thresholding	Global Thresolding
		Local Thresolding
		Dynamic Adaptive Thresolding
	Region Operating	Region growing
		Region Splitting and Merging
Special Theory Based	Clustering	K-means
		Fuzzy
	Neural Network	
Model Based		

A. **Segmentation Based on Edge Detection**

Edge detection is currently becoming a problem of fundamental importance in image analysis, even if it is one of the different image segmentation techniques. In typical images, edges characterize object boundaries, and are therefore useful for segmentation and detection of objects in a scene. [2][6]

Edge detection is a term in image processing and computer vision, it refers to algorithms which aim at identifying points in a digital image at which there is an abrupt change in image brightness or more formally, has discontinuities or simply where there is a jump in intensity from one pixel to the next [6]

There are many ways to perform edge detection, however, the majority of different methods may be grouped into two categories:

1. Gray Histogram Technique

In this technique, segmentation depends upon the selection on threshold Thr. This method is very efficient as compared to other segmentation methods. Firstly depending upon the colour or intensity a histogram is calculated from the entire pixel in the image, and then edges and valleys in image are located. This method found difficult to use when significant edges and valleys in the images were identified.[9][12]

2. Gradient Based Method

Gradient is the first derivative for image f(x, y), when there is abrupt change in intensity near edge and there is little image noise, gradient based method works well. This method involves convolving gradient operators with the image. High value of the gradient magnitude is possible place of rapid transition between two different regions. These are edge pixels, they have to be linked to form closed boundaries of the regions. Common edge detection operators used in gradient based method are sobel operator, canny operator, Laplace operator, Laplacian of Gaussian (LOG) operator & so on, [2] canny is most promising one , but takes more time as compared to sobel operator. Edge detection methods requires a balance between detecting accuracy and noise immunity in practice, if the level of detecting accuracy is too high, noise may bring in fake edges making the outline of images unreasonable and if the degree of noise immunity is too excessive, some parts of the image outline may get undetected and the position of objects may be mistaken. Thus, edge detection algorithms are suitable for images that are simple and noise-free as well often produce missing edges or extra edges on complex and noisy images.[3]

B. **Region Based Segmentation Methods**

Edge-based segmentation partitions an image based on abrupt changes in intensity near the edges whereas region based segmentation partitions an image into regions that are similar according to a set of predefined criteria. Thresholding, region growing, region splitting and merging are the main examples of techniques in this category[8]

1. Thresholding Method

Thresholding techniques are image segmentations based on image-space regions. The fundamental principle of thresholding techniques is based on the characteristics of the image. [5] It chooses proper thresholds T to divide image pixels into several classes and separate the objects from background. When there is only a single threshold T , any point (x, y) for which $f(x, y)>T$ is called an object point; and a point (x, y) is called a background point if $f(x, y) <T$. According to the aforementioned discussion, thresholding can be viewed as an operation to gain threshold T in the following equation:

$T = M[x, y, p(x, y), f(x, y)]$ ……..(1)

In this equation, T stands for the threshold; $f(x, y)$ is the gray value of point (x, y) and $p(x, y)$ denotes some local property of the point—such as the average gray value of the neighborhood centered on point (x, y) . [8]

Based on (1), thresholding techniques can be mainly divided into global, local, and dynamic thresholding techniques.

1) Global thresholding

Intensity distribution of object and background pixel are sufficiently distinct, then it is possible to use a global (single) threshold on the entire image. When 'Thr' depends only on the grey level value of image and 'Thr' is solely related to the properties of pixel in the image, this technique is called global thresholding. There are so many global thresholding methods are presented such as Otsu method, entropy based thresholding and so on.[12]

2) Local thresholding

If threshold T depends on both $f(x, y)$ and $p(x, y)$, this thresholding is called local thresholding . This method divides an original image into several sub regions, and chooses various thresholds *Ts* for each sub region reasonably.[5] After thresholding, discontinuous gray levels among sub images must be eliminated by gray level filtering technique. Main local thresholding techniques are simple statistical thresholding, 2-D entropy-based thresholding, histogram-transformation thresholding etc.[8]

3) Dynamic thresholding

If, in an image, there are several objects taking up different gray level regions, the image should be partitioned with vary dynamic thresholds(T_1、T_2、…T_n), depending on $f(x, y)$, $p(x, y)$and the spatial coordinates x and y. In general, dynamic thresholding techniques include thresholding image, Watershed, interpolatory thresholding and so on[8].

2. Region Operating Methods

The main purpose of image segmentation is to segment an image into the homogenous regions. In previous section, by selecting some thresholding based on the pixel properties in image segmentation were completed. In this section, by using regionbased operating technique the complete required region is found directly. However, it has one disadvantage that it requires lots of computational time.[12]

1) Region Growing

The basic idea of region growing method is a collection of pixels with similar properties to form a region. The steps are as follows[1]:

(i) find a seed pixel as a starting point for each of needed segmentation.

(ii) Merge the same or similar property of pixel (Based on a pre-determined growing or similar formula to determine) with the seed pixel around the seed pixel domain into the domain of seed pixel.

(iii) These new pixels act as a new seed pixel to continue the above process until no more pixels that satisfy the condition can be included.[1]

2. Region Splitting and Merging

In previous section, region is grows by selecting a set of seed points. But in this technique, the image Subdivided into a set of arbitrary disjoints regions and then merge and/or split the region according to the given condition for segmentation. Splitting influences overall region based segmentation. Particular splitting technique has a convenient representation in the form of so-called quad trees that is tree in which each node has exactly four branches.[10] For this the steps are as follows;

- Split the region into the four disjoint branches.
- When no further splitting is possible, merge any region.
- Stop when no further merging is possible.

In this way, by splitting and merging technique the segmentation was complete. This is somewhat complex and time-consuming method.[12]

C. THEORY BASED SEGMENTATION

In image segmentation, various image segmentation algorithms were derivative from different fields, which are very important for segmentation approach. Such as genetic algorithm, wavelet-based technique, fuzzy-based technique, neural network-based technique, clustering based and so on.[12]

1. Clustering Techniques

Clustering can be termed here as a grouping of similar images in the database. Clustering is done based on different attributes of an image such as size, color, texture etc.The purpose of clustering is to get meaningful result, effective storage and fast retrieval in various areas.

1) Fuzzy c means clustering

The purpose of clustering is to identify natural groupings of data from a large data set to produce a concise representation of a system's behavior. Fuzzy c-means (fcm) is a dat clustering technique in which a dataset is grouped into n clusters with every datapoint in the dataset belonging to every cluster to a certain degree.[4]

2) *K-Means Algorithm*

In K-means algorithm data vectors are grouped into predefined number of clusters . At the beginning the centroids of the predefined clusters are initialized randomly. The dimensions of the centroids are same as the dimension of the data vectors. Each pixel is assigned to the cluster based on the closeness, which is determined by the Euclidian distance measure . After all the pixels are clustered, the mean of each cluster is recalculated. This process is repeated until no significant changes result for each cluster mean or for some fixed number of iterations.[10]

2. Neural Network-based segmentation

Neural network based segmentation is totally different from conventional segmentation algorithms. In this algorithm, an image is firstly mapped into a neural network where every neuron stands for a pixel. Then, we extract image edges by using dynamic equations to direct the state of every neuron towards minimum energy defined by neural network.[8] Neural network based segmentation has three basic characteristics : *1)* highly parallel ability and fast computing capability, which make it suitable for real-time application; *2)* unrestricted nonlinear degree and high interaction among processing units, which make this algorithm able to establish modeling for any process;*3)* satisfactory robustness making it insensitive to noise. However, there are some drawbacks of neural network based segmentation either, such as: *1)* some kinds of segmentation information should be known beforehand; *2)* initialization may influence the result of image segmentation; *3)* neural network should be trained using learning process beforehand, the period of training may be very long, and we should avoid overtraining at the same time[8].

D. Model-Based Segmentation

Major advantages in medical imaging provided physician with powerful non invasive technique to probe the structure, function, and pathology of human body.[13] All segmentation techniques discussed so far utilize only local information. The human vision system has the ability to recognize objects even if they are not completely represented. It is obvious that the information that can be gathered from local neighborhood operators is not sufficient to perform this task. Instead specific knowledge about the geometrical shape of the objects is required, which can then be compared with the local information. This train of thought leads to *model-based segmentation.* It can be applied if we know the exact shape of the objects contained in the image.[5]

IV. CONCLUSIONS

In this paper, we classify and discuss main image segmentation algorithms; introduce the evaluation of image segmentation systemically; evaluate and compare basic, practical segmentation algorithms after a large number of comparative experiments[3][12]. Based on this, we now discuss the prospect of image segmentation. As the basic technique of image processing and computer vision, image segmentation has a promising future and the universal segmentation algorithm has become the focus of contemporary research [8].

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