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A SURVEY OF IMAGE SEGMENTATION TECHNIQUES

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Abstract

Image segmentation and its classification is difficult but important problem in computer vision.The main objective of image segmentation is to extract various features of the image that are used for analyzing, interpretation and understanding of images.It divides a digital image into multiple regions in order to analyze them.It is also used to distinguish different objects in the image.In this paper we have critically analyzed various segmentation techniques such as thresholding, edge based segmentation, fuzzy theory based segmentation, region based segmentation, clustering and also covered image segmentation overview such that its major types, classification and applications.

Keywords: clustering, CSF, Fuzzy, WM, GM

1. Introduction

Image segmentation is a very interesting area of research for image processing.We considers images as one of the most important medium to convey information in the field of computer vision.Image segmentation is a process in which we divide the image into disjoint regions that are meaningfull. The goal of image segmentation is to cluster pixels into salient image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects.we divide the image into multiple segments i.e. set of pixels,pixels in a region are similar to each other in some criteria such as color intensity or texture, so as to locate and identify objects and boundaries in an image.Image segmentation is the foundation of object recognition.Image segmentation is the first step in image analysis. 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. 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 f1 , f2, f 3,…… fn , which provides convenience to extraction of attribute.

Example Segmentations: Simple Scenes

Segmentations of simple gray-level images can provide useful information about the surfaces in the scene.

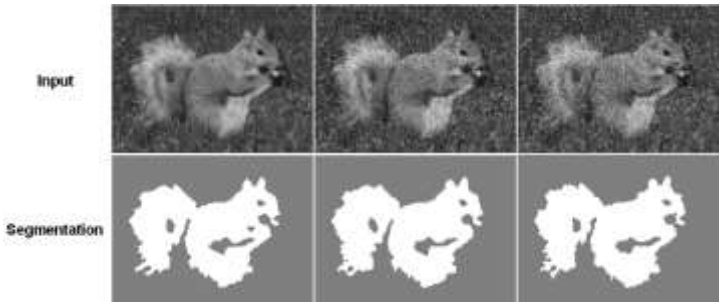

Figure 1: Segmentation

Famous techniques of image segmentation which are still being used by the researchers are Edge Detection, Threshold,Histogram,Region based methods, and Watershed Transformation.we divide the image into two parts.one part is related to region of interest and the other one is rest of the part of image.so we use image segmentation to seperate these two parts.So three main approaches of image segmentation are threshold,edge detection and region based segmentation.The result which we get from image segmentation is further used for image processing research.There are many application areas of image segmentation such as 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, Fingerprint Recognition, etc.

Different techniques of image segmentation are-

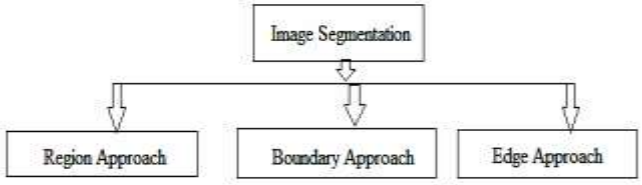

Figure 2: different segmentation techniques

a. Threshold Based

Thresholding is an old, simple and popular technique for image segmentation. Image segmentation by thresholding is a simple but powerful approach for segmenting images having light objects on dark background. Thresholding operation convert a multilevel image into a binary image i.e., it choose a proper threshold T, to divide image pixels into several regions and separate objects from background. Any pixel (x, y) is considered as a part of object if its intensity is greater than or equal to threshold value i.e., $f(x, y) \geq T$, else pixel belong to background.There are two types of thresholding methods.They are catagorised as global and local thresholding.If T is constant then it is known as global thresholding otherwise it is local thresholding. Global thresholding methods can fail when the background illumination is uneven. In local thresholding, multiple thresholds are used to compensate for uneven illumination.

There are certain disadvantages of thresholding method. only two classes are generated, and it cannot be applied to multichannel images.Thresholding does not take into account the spatial characteristics of an image so it is sensitive to noise.This corrupt the histogram of the image, making separation more difficult.

a.1. Threshold Selection

Segmentation using thresholding technique is the choice of selecting threshold value T. Automatically selected threshold value for each image by the system without human intervention is called

an automatic threshold scheme. In case of automatic threshold selection method, the value of T can be chosen based on histogram, clustering, variance, means etc

a.2. Histogram Based Threshold Selection

The histogram based techniques is dependent on the success of the estimating the threshold value that separates the two homogonous region of the object and background of an image. Histogram based thresholding is applied to obtain all possible uniform regions in the image.
Let P1 and P2 be the gray value of the peaks of the histogram. The threshold value T is given by eq. (1)

$$T= (P1 +P2)/2 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

a.3. EMT Technique

The threshold image by using edge maximization technique (EMT) is used when there are more than one homogenous region in image or where there is a change on illumination between the object and its background. In this case portion of the object may be merged with the background or portions of the background may as an object. To this reason any of the automatic threshold selection techniques performance becomes much better in images with large homogenous and well separated regions. This techniques segmentation depend on the research about the maximum edge threshold in the image to start segmentation that image with help the edge detection techniques operators.

b. Edge Based

Edge-based segmentation represents a large group of methods based on information about edges in the image.Edge-based segmentations rely on edges found in an image by edge detecting operators -- these edges mark image locations of discontinuities in gray level, color, texture, etc. Segmentation Methods based on Discontinuity find for abrupt changes in the intensity value. These methods are called as Edge or Boundary based methods .Edge detection techniques are generally used for finding discontinuities in gray level images.

Figure 3: edge based segmentation

There are many methods for edge detection, but most of them can be grouped into two categories, search-based and zero-crossing based. The search-based methods detect edges by first computing a measure of edge strength, usually a first-order derivative expression. The zero-crossing based methods search for zero crossings in a second-order derivative expression computed from the image in order to find edges.

b.1. 1st order Derivative

1) **Prewitt operator**- it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt operator is either the corresponding gradient vector or the norm of this vector. The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical directions and is therefore relatively inexpensive in terms of computations.

2) **Sobel operator**- it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding gradient vector or the norm of this vector. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations.

3) **Canny operator-** The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. It was developed by John F. Canny in 1986. Canny also produced a *computational theory of edge detection* explaining why the technique works.

b.2. 2nd Order Derivative

1) **Laplacian operator**- There must exist a point where there is a zero crossing. That point is the edge's location. Edge detectors that are based on this idea are called Laplacian edge detectors.

2) **Zero-crossings-** In the field of Digital Image Processing, great emphasis is placed on operators which seek out edges within an image. They are called 'Edge Detection' or 'Gradient filters'. A gradient filter is a filter which seeks out areas of rapid change in pixel value. These points usually mark an edge or a boundary. A Laplace filter is a filter which fits in this family, though it sets about the task in a different way. It seeks out points in the signal stream where the digital signal of an image passes through a pre-set '0' value, and marks this out as a potential edge point. Because the signal has crossed through the point of zero, it is called a zero-crossing.

c. Region Based

In this we examine neighbouring pixels and detect whether the neighbour pixel should be added or not.Region based segmentation technique attempts to group the pixels with similar characteristics (such as approximate Gray level equality) into regions. There are two approaches in region-based methods:
-region growing
-region splitting and merging

In the region growing process the Seed region is expanded to include all homogeneous Neighbors and the process is repeated.The process ends when there is no pixel to be classified.In region splitting method the process starts with the entire image as a seed.If the seed is inhomogeneous then it splits into predetermined number of subregions,typically four.T he region splitting process is then repeated using each subregion as a seed.The process ends when all subregions are homogeneous.In *Region Merging Method* ,Merge any adjacent regions that are similar enough.

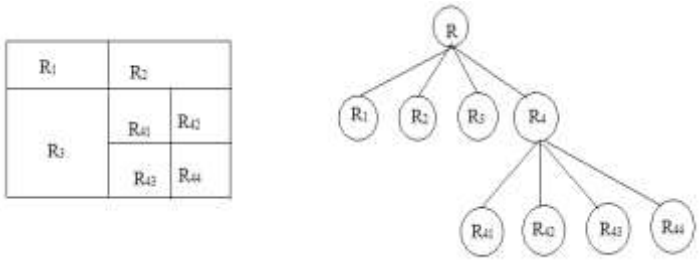

Figure 4: region base segmentation

d. Clustering

One natural view of segmentation is that we are attempting to determine which components of a data set naturally "belong together". This is a problem known as clustering. Clustering is an unsupervised learning task, where one needs to identify a finite set of categories known as clusters to classify pixels [8].Principle of clustering is maximizing the intraclass similarity and minimizing the interclass similarity. 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[11].

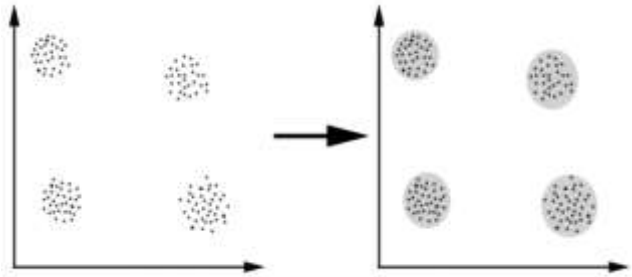

Figure 5: clustering

Two popular methods of clustering are-

d.1. K-mean Clustering

K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. 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].

d.2. Fuzzy Clustering

Fuzzy c-means (fcm) is a that 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 [11].Fuzzy clustering method can be considered to be superior to those of their hard counterparts since they can represent the relationship between the input pattern data and clusters more naturally. Fuzzy c-means is a popular soft-clustering method, its effectiveness is largely limited spherical clusters.Fuzzy c-means is one of the most promising fuzzy clustering method. In most cases, it is more flexible than the corresponding hard-clustering algorithm [8].

2. Literature Review

There are many algorithms used for image segmentation, and some of them segmented an image based on the object while some can segment automatically. Nowadays, no one can point out which the optimal solution is due to different Constraints.

DR.S.V.Kashmir Raja, A.Shaik Abdul Khadir, DR.S.S.Riaz Ahamed compared the performances of the two popular region-based image segmentation methods namely the Watershed method and the Mean-shift method. Finally they concluded that the Watershed image segmentation method has shown better performance than the Mean-Shift image segmentation method [1].

G. Evelin Sujji1,Y.V.S. Lakshmi, G. Wiselin Jiji outlined an efficient image segmentation technique that can distinguish the pathological tissues such as edema and tumour from the normal tissues such as White Matter (WM), Grey Matter (GM), and Cerebrospinal Fluid (CSF). This approach for segmentation of MRI brain images can help in the proper detection of the region of interest [2].

Muhammad Waseem Khan discussed and evaluated main image segmentation techniques used for the purpose of image analysis. It is found that there is no perfect method for image segmentation because the

result of image segmentation is depends on many factors, i.e., pixel color, texture, intensity, similarity of images, image content, and problem domain [4].

Salem Saleh Al-amri1, N.V. Kalyankar and Khamitkar S.D attempted to undertake the study of segmentation image techniques by using five threshold methods as Mean method, P-tile method; Histogram Dependent Technique (HDT), Edge Maximization Technique (EMT) and visual Technique and they are compared with one another so as to choose the best technique for threshold segmentation techniques Image [5].

Fari Muhammad Abubakar1 attempted to study Image Segmentation using Thresholding Technique on an image corrupted by Gaussian Noise as well as Salt and Pepper Noise which is implemented using MATLAB version7.12.0.635 (R2011a) software and the results obtained are studied and thereby discussed, highlighting the techniques performance.The study made use of the Iterative algorithm for the purpose of Image Thresholding on an image with pixel size 500x699 and the results obtained in the experiment were studied thereby highlight the performance of this image segmentation technique[10].

Rajeshwar Dass,Priyanka,Swapna Devi described the different segmentation techniques used in the field of ultrasound and SAR Image Processing.They investigates and compiles some of the technologies used for image segmentation. Then a bibliographical survey of current segmentation techniques is given. and finally general tendencies in image segmentation are presented[12].

S.Dhanalaxmi and Dr. T.Ravichandaran used new image segmentation algorithms based on information bottleneck method. Here they used three algorithms; first they introduce the split-and-merge algorithm, where an image is segmented into set of regions (input) and the intensity histogram bins (output) is obtained. The second algorithm is the histogram clustering algorithm, where the input variable represents the histogram bins and the output is given by the set of regions. Finally, the registration based segmentation for two registered multimodal images [13].

Pedro F. Felzenszwalb and Daniel P. Huttenlocher addressed the problem of segmenting an image into regions. They define a predicate for measuring the evidence for a boundary between two regions using a graph-based representation of the image and then develop an efficient segmentation algorithm based on this predicate. An important characteristic of the method is its ability to preserve detail in low-variability image regions while ignoring detail in high-variability regions [16].

Gurjeet kaur Seerha and Rajneet Kaur focused on study of recent automatic image segmentation algorithms.Some recently proposed methods are Dynamic region merging, Fuzzy algorithm, Relay Level set method[20].

3. Critical Analysis

Table 1. Comparison of image segmentation techniques.

Segmentation technique	description	advantages	disadvantages	applications
thresholding	Requires that the histogram of an image has a number of peaks, each correspond to a region [8]	It does not need a prior information of the image.And it has less computational complexity	May be difficult to identify significant peaks and valleys in the image.It donot take into account the spatial detail so the segmented regions may not be contigous.	Medical imaging, Locate tumors and other pathologies

Edge-based	Based on the detection of 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 regions.	a)Does not work well with images in which the edges are ill-defined or there are too many edges; b)It is not a trivial job to produce a closed curve or boundary)Less immune to noise than other techniques	Medical imaging,,face detection
Region-based	Group Pixels into homogeneous regions. Including region growing, region splitting, region merging or their combination	We could split the image using the criteria we decide, such as mean or variance of segment pixel value. In addition, the merging criteria could be different to the splitting criteria.	a. It may produce the blocky segments. b. Are by nature sequential and quite expensive both in Computational time and memory.	Neural network edge pattern,pixel aggregation,3D Reconstruction of Shape and Piecewise Constant Radiance
clustering	Assumes that each region in the image forms a separate cluster in the feature space. Can be generally broken into two steps:(1)categorize the points in the feature space into clusters; (2) map the clusters back to the spatial domain to form separate regions. Apply k-mean and fuzzy method	a. The process and relationships of hierarchical clustering can just be realized by checking the dendrogram. b. The result of hierarchical clustering presents high correlation with the characteristics of original database. c.Straightforward for classification and easy to implement	a. For the reason that hierarchical clustering involves in detailed level, the fatal problem is the computation time. b. Features are often image dependent and how to select features so as to obtain satisfactory segmentation results Remains unclear. c. Does not utilize spatial information	Measure tissue volumes,

4. Conclusion

In this review of image segmentation study, the overview of various segmentation methodologies applied for digital image processing is explained briefly. Though many techniques are developed, not all types are useful for all types of images. It is found that there is no perfect method for image segmentation because the result of image segmentation is depends on many factors, i.e., pixel color, texture, intensity, similarity of images, image content, and problem domain. Therefore, it is not possible to consider a single method for all type of images nor all methods can perform well for a particular type of image [4].

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