A Comprehensive Study of Image Segmentation

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***Abstract*-In Image processing is divide an image into its constituent regions or objects is called segmentation. It means partition an image into distinct regions which are related with features of interest or objects in image. We can also say, segmentation is grouping of pixels with same attributes. Segmentation is very important in image processing field as, it is normally a first stage in any attempt to interpret image automatically. In this paper, we have done the study of different methods available for image segmentation and show the comparison of all methods. We have briefly explained all the methods available to do image segmentation.**

Keywords--- Segmentation, thresolding, region based

I. INTRODUCTION

Mathematically, image segmentation is a process which partitions image pixels into non-overlapping regions where each region is connected as well as homogeneous and union of nearby regions is not homogeneous. As in image segmentation we divide image into different regions, so the level of segmentation is depend on our application. Segmentation process stops when we get the object of our interest [15]. Below we have shown the example of one image and corresponding segmented image.

Figure 1: Example of segmentation

Image segmentation is very important in the field of image processing. For image analysis, segmentation is very crucial. If segmentation process is not proper then all the analysis goes wrong. Though exact and accurate automatic image segmentation is very difficult to achieve. It fills the gap between high and low level of image processing. In most of the object identification, reorganization and measurement technique, segmentation is used. Image segmentation can be used in Optical character reorganization (OCR), Industrial inspection, Object tracking in a sequence of images, in satellite images for Classification of terrains, in medical images for Detection and measurement of tissue [20], bone etc.

Image segmentation can be classified as similarity and discontinuity based on intensity values. In discontinuity approach, based on unexpected changes in intensity we partition image while in similarity based approach, based on some predefined criteria we partition image with similar regions.

Segmentation algorithms can be dividing in terms of color image segmentation, gray scale image segmentation and text image segmentation.

Paper is organized as follow: In section 2, we have briefly describe different methods (algorithms) of image segmentation, Section 3 contain comparison of all algorithms. In section 4, we have reviewed some recent research paper for image segmentation and finally Section 5 contains conclusion and future work.

II. METHODS OF IMAGE SEGMENTATION

Here we have briefly explained methods available for segmentation like thresolding, clustering, compression based, edge detection, histogram based, region growing, multi scale, model based, split and merge, partial differential equation based and others.

We can broadly classify image segmentation in following categories:

Edge Based	Gray Histogram	
	Gradient Based	Differential Coefficient
		LoG
		Canny Technique
Region Based	Thresholding	Otsu
		Optimal thresholding
		Thresholding Image
	Region Operating	Region growing
		Region splitting and merging
		Image mapping
Special Theory based	Fuzzy clustering	
	Neural network based	
	Physically based	

A. Thresolding

In this method, to convert gray scale image into binary image, one clip level(threshold value) is chosen[11]. When multiple levels are selected, more than one threshold values are needed. Popular threshold methods are k-means clustering, Otsu's method and maximum entropy method. Recently new method of thresolding has been developed for CT (computed tomography) images. Here from radiographs, thresholds are derived.

B. Clustering methods

K-means algorithm is used for clustering. It is an iterative technique. Basic algorithm is: Based on some heuristic (or randomly) Pick X cluster centers, Put pixel in cluster which reduce pixel and cluster center distance (squared or absolute difference between cluster center and pixel), by averaging all pixel again, re-compute cluster center, do all this till no pixels change clusters. Difference is based on pixel intensity, texture, color or location. This algorithm may not return the optimal answer. Lloyd's algorithm is used as iterative refinement heuristic.

C. Compression-based methods

Compression based methods describes each segment using its boundary shape and texture. Connection between compression and segmentation concepts is that segmentation tries to find patterns and regularity in image can be used to compress it [8]. In this method, from all available segmentations of image, task is to search the segmentation which produces the shortest coding length. Agglomerative clustering method is there to achieve this thing.

D. Histogram-based methods

In this method only one pass through pixel is needed so this is very efficient algorithm [15]. In this method, histogram for image is created and valley and peaks are used to find out clusters. For measure color and intensity can be used. For improvement in basic algorithm, we can recursively apply same algorithm for getting smaller clusters. If peaks and valleys are not able to identified, then this algorithm can't perform properly. In video tracking, this method can be used.

E. Edge detection

Edge detection is used as base of segmentation technique. Edges are normally disconnected. On Edges obtain from edge detector Segmentation methods can be applied. Lindeberg and Li [23] have developed integrated method for parts-based object recognition which segments edges into straight and curved edge segments.

F. Region-growing methods[13]

The seeded region growing method was the first region growing method. Here seeds are provided as input which marks objects to be segmented. Iteratively regions are grown by comparison of unallocated neighboring pixels. Result of segmentation is fully depending on seeds. Noise can cause poor seeds selection. Haralick and Shapiro (1985) proposed one method, which is based on pixel intensities. To compute test statistic, the intensity of the candidate pixel andthe mean and scatter of the region is used. A λ-connected segmentation is special region growing method which is based on neighborhood liking path and pixel intensities.

G. Split-and-merge methods[22]

Split-and-merge segmentation is sometime called quad tree segmentation as it is based on a quad tree partition of an image. Method starts from the root of the tree(represents the whole image) and If it is not homogeneous then it is split into four son-squares and so on. Process ends when no more splits or merges possible. For optimal algorithm, Time complexity can reach. $O(n \log n)$

H. Partial differential equation-based method

By solving partial differential equation (PDE) equation using numerical scheme we can segment image [8]. In this category Curve propagation is very popular. Basic idea is to develop initial curve towards the lowest potential of a cost function(its definition reflects the task to be addressed).

I. Parametric methods[8]

This technique is efficient and fast. Lagrangian techniques is example of this technique. Limitations regarding the choice of sampling strategy original "purely parametric" formulation given by Kass and Terzopoulos in 1987 (known as "snakes"), is criticized. High Efficient "discretized" formulations have been developed nowadays to address limitations.

J. Level set methods [8]

This method was proposed in 1988 by Osher and Sethian. Basic idea of the method is to present evolving counter using signed function and after that using motion equation of counter, we can derive same flow for surface which is implicit. This method is parameter free, implicit and one can directly estimate geometric properties of evolving structure.

K. Graph partitioning methods

In this method, image is modeled as undirected weighted graph. Normally pixel (or group of pixels) associated with nodes and weights of edge. They define similarity between neighboring pixels. Then graph is partitioned according to some predefined criteria which generate cluster. Random walker, minimum cut and normalized cut are some of the most popular algorithm of this category.

L.Watershed transformation

This method considers the gradient magnitude of image as a topographic surface. Pixels with maximum GMIs (gradient magnitude intensities) are correspond to region boundaries which represented by watershed lines. Segment represented by pixels draining to common minimum form catch basin.

M. Model based segmentation

In this method we assume that structure of object has repetitive form of geometry. So we need probabilistic model. So task involved here are: registration of training examples, probabilistic representation of registered samples, statistical relation between image and model.

N. Multi-scale segmentation

Segmentation is propagated from fine to coarse scale. Criteria for segmentation can be complex and can take global and local both criteria in account. Only one basic requirement is that, all regions must be connected in some sense.

O. Image segmentation and primal sketch

Work on how iso- intensity counter works over different scales is initially done by Koenderink [12]http://en.wikipedia.org/wiki/Segmentation_(image_processing)_-_cite_note-22 and then by Lifshitz and Pizer[14].http://en.wikipedia.org/wiki/Segmentation_(image_processing)_-_cite_note-23 Problem in this method is, intensity varies as scale varies. Lindeberg [16][17] proposed scale-space primal sketch image representation which gives relation between structure at different scales. To detect edges in scale-space at coarse scales Bergholm proposed one method. Gauch and Pizer[5] develope a tool for interactive segmentation based on multi-scale watersheds using study of ridges and valleys at multiple scales. Undeman and Lindeberg [3] proposed fully automatic brain segmentation algorithm based on multi-scale watersheds and tested on brain databases.

P. Trainable Segmentation

In Neural Network segmentation, a small area of an image is processed using an artificial neural network [6].Kohonen map is normally designed for network. For high performance biometric image processing, by modeling a cat's visual cortexPulse-coupled neural networks (PCNNs) models are proposed by Eckhorn.Model provided good support for studying mammal's visual cortex. Model was adapted by Johnson, who proposed one algorithm called Pulse-Coupled Neural Network. A PCNN is a neural network with two-dimensional. Advantages of PCNNs are: capability of bridging minor intensity variations in input patterns, robustness against noise,

independence of geometric variations in input patterns etc.

III.COMPARISION OF IMAGE SEGMENTATION ALGORITHMS

Here we have shown comparison for edge detection algorithms and thresholding methods [21].

Edge Detection Method	**Advantages**	**Disadvantages**
sobel	Simplicity	inaccurate and very sensitive to noise
Zero crossing	Edges and their orientations can be detected and for all direction same fixed characteristics.	Sensitive to noise
Robert	Simplicity	Very sensitive to noise
Gaussian Edge Detectors	In noisy environment also give good result	Complex to understand and Time consuming
Canny	Give good Performance	More complex
Laplacian of Gaussian (LoG)	Position of edges can be found correctly as wider area around the pixel is consider for testing	Poor at the curves, corners, and where the gray level intensity function varies.
Thresholding Method	**Advantages**	**Disadvantages**
Iterative threshold-ing	complexity is average Segmentation effect is good	Image details are fuzzy
Minimum Thresholding	Low complexity	Narrow in application Segmentation effect is normal
Otsu thresholding	Combine with other algorithm to improve its performance Segmentation effect is good	Complexity is very high
Entropy based thresholding	Complexity is very low	Sensitive to noise Segmentation effect is normal

IV.RECENT WORK

We have studied some of the recent papers on segmentation and here we have briefly explained all of them.

In [4], they present figure-ground segmentation technique. Here they separate foreground and background objects. Main idea in this paper is transferring segmentation masks from training windows which are similar to test image windows. Their approach gives good results on PASCAL VOC 2010 segmentation challenge, Graz-02 and Weizmann horses. Below diagram shows their method.

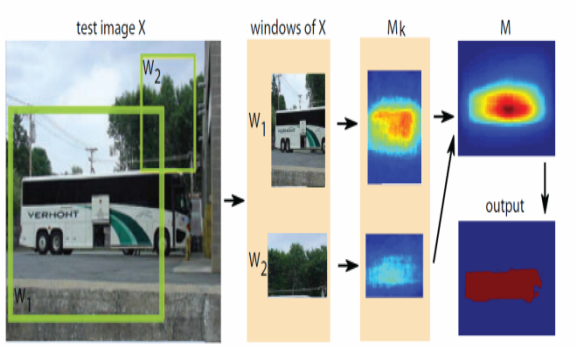

Figure 2: Figure ground segmentation

In paper [24], authors present segmentation technique which automatically leans parameter of segmentation. This method does not require offline parameter tuning or training stage. This method takes parameter through user interaction. They use CRF (conditional random field). Their results outperform many other interactive segmentation methods. Below diagram shows their method.

Figure 3: Segmentation which learn parameter automatically [24]

In paper [19], they proposed segmentation method for images where multiple image images of same environment are available. Their method,

corresponding to background finds pixels from image by comparing it with other same scene image. They demonstrate results on challenging outdoors data set. Below diagram shows this method.

Figure 4: multiple image segmentation [19]

We have studied paper[2] in detail. In paper, they do segmentation in region merging style. They merge regions of initially segmented image using statistical test. They use SPRT (sequential probability ratio test) and minimal cost criterion. They show that merging order follows dynamic programming. They maintain NNG(nearest neighbor graph) in all iteration. Using merging nodes of NNG can be reduce which shows in below diagram.

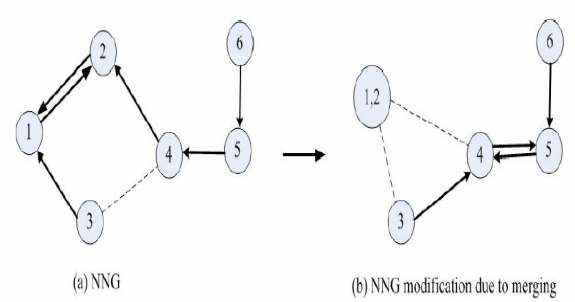

Figure5 : segmentation which use NNG[2]

They accelerate dynamic region merging process using one algorithm which we have listed here.
Initial RAG and NNG of the image is input to algorithm and output will be RAG (region merging result).
Take i=0 and for NNG,i-thgraph layer find minimum weight edge. Then check value of predicate and corresponding to that merge regions. Update RAG, NNG and cycles accordingly. Now take
i=i + 1.Do all this procedure till we not get any more cycle.

V.CONCLUSION AND FUTURE WORK

Segmentation is one of the most important techniques for image analysis. There are many image segmentation algorithms available. According to the application and images available we can use the best appropriate method.

In future we would like to implement all recent of above listed methods and want to compare them. We would like to modify some of the methods if modification can improve their performance and we would like to propose our own method for segmentation which would be region based.

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