A REVIEW ON IMAGE SEGMENTATION TECHNIQUES

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Abstract

Image Segmentation is the process of dividing an image into various pars in order to identify objects and certain other important information stored in the digital image .It is the fundamental step to analyze images and extract data from them. It is the field widely researched and still offers various challenges for the researchers. This paper 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. Image segmentation is a crucial step as it directly influences the overall success to understand the image. In image analysis, segmentation is the partitioning of a digital image into multiple regions (sets of pixels), according to some homogeneity criterion. For each algorithm, we consider its correctness as measured by the NPR index, as well as its stability with respect to changes in parameter settings and with respect to different images. An algorithm which produces correct segmentation results with a wide array of parameters on any one image, as well as correct segmentation results on multiple images with the same parameters, will be a useful, predictable and easily adjustable preprocessing step in a larger system.This paper produces a comperative study of different segmentation algorithms on different parameters .

Keywords: Objects,Segmentation, Pixels ,NPR Index

I. INTRODUCTION

Unsupervised image segmentation algorithms have matured to the point that they provide segmentations which agree to a large extent with human intuition. The time has arrived for these segmentations to play a larger role in object recognition. it is clear that unsupervised segmentation can be used to help cue and refine various recognition algorithms. However, one of the stumbling blocks that remain is that it is unknown exactly how well these segmentation algorithms perform from an objective standpoint.

Most presentations of segmentation algorithms contain superficial evaluations which merely display images of the segmentation results and appeal to the reader's intuition for evaluation. There is a consistent lack of numerical results, thus it is difficult to know which segmentation algorithms present useful results and in which situations they do so. Appealing to human intuition is convenient, however if the algorithm is going to be used in an automated system then objective results on large datasets are to be desired. in this paper we present the results of an objective evaluation of two popular segmentation techniques: mean shift segmentation [1], and the efficient graph-based segmentation algorithm presented in [2]. As well, we look at a hybrid variant that combines these algorithms.

For each of these algorithms, we examine three characteristics:

1. Correctness: the ability to produce segmentations which agree with human intuition. That is, neither segmentation which correctly identify structures in the image at neither too fine nor too coarse a level of detail.
2. Stability with respect to parameter choice: the ability to produce segmentations of consistent correctness for a range of parameter choices.
3. Stability with respect to image choice: the ability to produce segmentations of consistent correctness using the same parameter choice on a wide range of different images. if a segmentation scheme satisfies these three characteristics, then it will give useful and predictable results which can be reliably incorporated into a larger system. The measure we use to evaluate these algorithms is the recently proposed Normalized Probabilistic Rand (NPR) index [3]. We chose to use this measure as it allows a principled comparison between segmentation results on different images, with differing numbers of regions, and generated by different algorithms with different parameters. Also, the NPR index of one segmentation is meaningful as an absolute score, not just in comparison with that of segmentation.

II. TECHNIQUES USED IN THE LITERATURE FOR IMAGE SEGMENTATION

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. in [4], a similarity close measure was used to classify the belonging of the pixels, and then used region growing to get the object. Unfortunately, it required a set of markers, and if there is an unknown image, it is hard to differentiate which part should be segmented. Linking the area information and the color histogram were considered for building video databases based on objects [5]. However, the color information has to be given first, and it is not useful for the life application. A genetic algorithm adapted the segmentation process to changes in image characteristics caused by variable environmental conditions [6], but it took time learning. in [7], a two-step approach to image segmentation is reported. it was a fully automated model-based image segmentation, and improved active shape models, line-lanes and live-wires, intelligent scissors, core-atoms, active appearance models. However, there were still two problems left. it is strong dependency on a close-to-target initialization, and necessary for manual redesign of segmentation criteria whenever new segmentation problem is encountered. The authors in [8] proposed a graph-based method, the cut ratio is defined following the idea of NP-hard as the ratio of the corresponding sums of two different weights of edges along the cut boundary and models the mean affinity between the segments separated by the boundary per unit boundary length. it allows efficient iterated region-based segmentation as well as pixel-based segmentation. Moreover, in order to understand an image and recognize the represented objects, it is necessary to locate in the image where the objects are [9]. The homogeneity between two pixels and the distance function are included to measure the segmented results Di =| i (x, y) - i (v,w) | [18]. in [32], a confidence level L min(p p),i, j 1,...,N. i j i j = - = is used as a new performance measure to evaluate the accuracy segmentation algorithm. in [1o], the minimizing function including the approximation mean square error RMSE and the number of distinct region tried to achieve a good segmentation result. in [11], edge detection is a fundamental concept for segmentation because it is easy not only to understand its principle but also to implement.
The segmentation of the image is very useful in medical applications to diagnose the abnormalities in the image [12][13], satellite imaging and in computer vision as well as in ANN. The criteria for segmenting the image is very hard to decide as it varies from image to image and also varies significantly on the modality used to capture the image. There is large amount of literature available to understand and analyze the segmentation techniques.
in [14] the clustering methods have been discussed for medical image segmentation in particularly for MR images of brain and are successful in combining fuzzy c means and k-means to get novel fuzzy-k means algorithm. Few limitations of the obtained algorithm have been also stated.
Hybrid technique for medical image segmentation is suggested in [15] and mainly works on fuzzy-c means and otsu's method after applying on vector median filter, for segmentation and have tried to prove the

robustness of their method few kinds of noise have been added to image and have obtained satisfactory result. A new technique for general purpose interactive segmentation of N-dimensional images using graph-cut method has been proposed by Yuri and Jolly [16]. in their proposed method the user marks certain pixels as "object" or "background" to provide hard constraints for segmentation. They claim that their method gives best balance of boundary and region properties compared to other segmentation methods and also that it provides optimal solution for N-dimensional segmentation.

The list of related works done in the field of image segmentation is very large and can hardly be mentioned. There are various survey and reviews [12] [17][13] done on these methods periodically.

There have been previous attempts at numerical image segmentation method comparisons, although the number is small. Here we describe some examples and summarize how our work differs. A comparison of spectral clustering methods is given in [18]. The authors attempted to compare variants of four popular spectral clustering algorithms: normalized cuts by Shi and Malik [19], a variant by Kannan, Vempala and Vetta [2o], the algorithm by Ng, Jordan and Weiss [21], and the Multicut algorithm by Meila and Shi [22], as well as Single and Ward linkage as a base for comparison. They also combined different parts of different algorithms to create new ones. The measure of correctness used was the Variation of information introduced in [23], which considers the conditional entropies between the labels in two segmentations. The results of this comparison were largely unexciting, with all of the algorithms and variants performing well on 'easy' data, and all performing roughly equally badly on 'hard' data. Another attempt at segmentation algorithm comparison is presented on the Berkeley database and segmentation comparison website [24]. Here a large set of images are made available for segmentation evaluation, and a framework is set up to facilitate comparison. Comparisons currently exist between using cues of brightness, texture, and/or edges for segmentation. However, there are no current examples of comparisons between actual algorithms which use the same features. The measure used for segmentation correctness is a precision-recall curve based on the correctness of each region boundary pixel. Different boundary thresholds are used to obtain different points on the curve. The reported statistic is the F measure, the harmonic mean of the precision and recall. This measure has the downside of considering only region boundaries instead of the regions themselves. Since region difference is a quadratic measure whereas boundary difference is a linear measure, small boundary imperfections will affect the measure more than they necessarily should.

III. KNOWLEDGE BASED APPROACHES TO SEGMENT AN IMAGE

There are many knowledge based approaches to segment an image and can be listed as

1. Intensity based methods
2. Discontinuity based methods
3. Similarity based methods
4. Clustering methods
5. Graph based methods
6. Pixon based methods
7. Hybrid methods

III .I Intensity Based Segmentation

One of the simplest approaches to segment an image is based on the intensity levels and is called as threshold based approach. Threshold based techniques classifies the image into two classes and works on the postulate that pixels belonging to certain range of intensity values represents one class and the rest of the pixels in the image represents the other class. The threshold based segmentation techniques are inexpensive, computationally fast and can be used in real time applications with aid of specialized hardware [25]

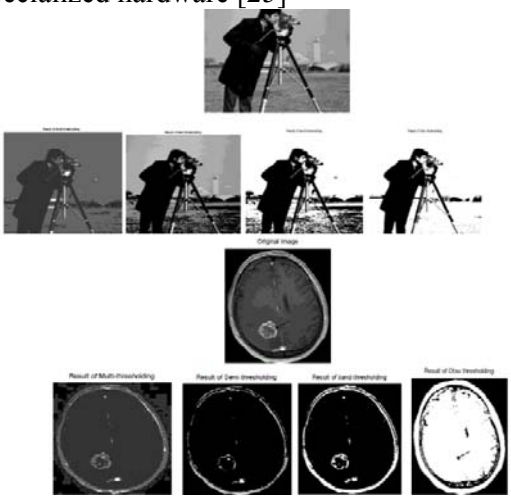

Figure 1: Images classified by using intensity based segmentati0n

Pros of threshold based methods:

1. Computationally inexpensive
2. Fast and simpler to implement
3. Can work in real-time applications [25]

Cons of threshold based algorithms:

1. Neglects the spatial information of the image.
2. Highly noise sensitive.
3. Selection of threshold value is crucial and often results in over or under segmentation.
4. May lead to pseudo edges or missing edges.[26]

III.II *Discontinuity Based Methods*

These methods are based on the principle of intensity variations among the pixels. if the image consists two or more objects boundaries exists and hence can be applied to segment the image. The boundaries of the objects lead to formation of edges. The significant abrupt changes in the intensity levels among neighboring pixels in certain direction are termed as edges and results in the discontinuity in the pixels. Edge detection basically involves the following steps: smoothing the image, edge detection and edge localization. A suitable smoothing filter is applied on test image to remove the noise from the image to make it suitable for segmentation. Edge detection operators can be broadly classified into two categories as: First order derivative operators and second order derivative operators. The operators used in First order derivative category are Robert‟s operator, Prewitt‟s operator and Sobel‟s operator. Second order Derivative operators are mainly as Laplacian of Gaussian operator [28], Canny Edge operator.

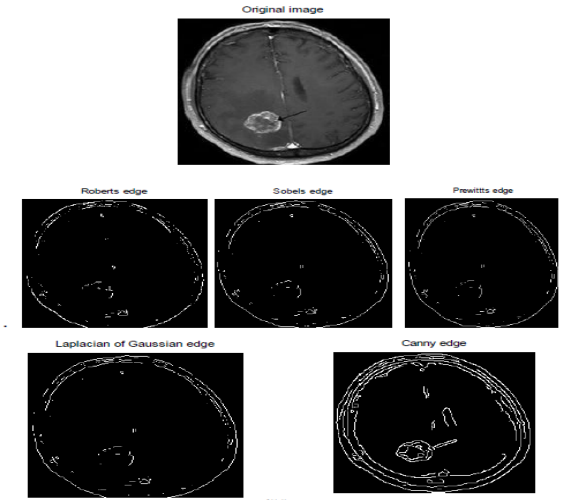

Figure 2: Classification 0f images by Canny Edge operator

III.*III.* *Region Based Segmentation*

This method works on the principle of homogeneity by considering the fact that the neighboring pixels inside a region possess similar characteristics and are dissimilar to the pixels in other regions.

The 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.

Region based methods are fundamentally divided as

1. Region growing methods
2. Region split and merge methods

Region growing methods: Region growing method gives reliable output compared to its other counterparts. it is basically extracting a region from the image using some pre-defined criteria.[1o]. The simplest procedure is to compare the candidate pixel to its neighbors to check the homogeneity criteria allocated to the class to which its neighbor belongs. it can be further classified as seeded region growing method (SRG) and unseeded region growing method (UsRG). The main difference between SRG and UsRG is that SRG is semi-automatic in nature whereas UsRG is fully automatic in nature.

Some of the region growing methods are as Seeded Region Growing method, Unseeded Region Growing method, Region Split and Merge method.

Figure 3: Results of region growing algorithms for segmenting images

III.IV *Clustering Based Methods*

Clustering is a process of organizing the groups based on its attributes. The objective of

clustering techniques is to identify bunch in data. A cluster usually contains a group of similar pixels that belongs to a specific region and different from other regions. images can be grouped based on its content. in content based clustering, grouping is done depending on the inherited characteristics of the pixels like shape, texture etc. The Clustering methods are usually divided as hierarchical algorithms and partitional algorithms. Some of the clustering methods are as Agglomerative clustering, Partitional clustering (K-means algorithm, Fuzzy C-Means [FCM] Algorithm) etc.

III.V *Hybrid Methods*

Hybrid methods combine one or more of the basic segmentation methods. These algorithms inherit the good quality of several approaches and gives better performance compared to its parent approach. The combination of threshold based and clustering methods [15] are used in medical image segmentations along with the region-edge based approaches[27], region – deformable models, region-edge-based with morphological watershed. Hybrid methods rely on morphological operations performed on images. The widely used techniques are watershed segmentation, variable-order surface fitting and active contour methods. The widely used techniques are watershed segmentation, variable-order surface fitting and active contour methods.

III.*VI Graph Based Methods*

Graph based methods for image segmentation has several good features in practical applications. it explicitly organizes the image elements into mathematically sound structures, and makes the formulation of the problem more flexible and the computation more efficient.

The graph based methods are categorized into five classes: the minimal spanning tree based methods, graph cut based methods with cost functions, graph cut based methods on Markov random field models, the shortest path based methods and the other methods that do not belong to any of these classes. Among the available techniques graph cut methods are widely used and was initially proposed by Yuri and marie [16].

III.VII *Pixon Based Method*

The pixon method is a nonlinear image reconstruction method that has decision levels as pixons instead of pixels. This method increases linear spatial resolution by few factor and sensitivity by the order of magnitude. This was introduced by pina & puetter in 1993. Another advantage of pixon based method is computational fastness compared to other methods. Traditional Pixon Based method is simple to approach and has only two steps of forming pixons and segmenting the image. Forming the pixon in this method has three steps: (i) achieve a pseudo image with same resolution as the observed image (ii) filter using anisotropic diffusion filter to achieve pixons (iii) use hierarchical clustering algorithms to extract pixons.

IV. COMPARATIVE STUDY

Now that we have described the algorithms we wish to compare, and a measure for comparison, we can finally describe the specific comparisons we wish to perform. We believe that there are two key factors which allow for the use of a segmentation algorithm in a larger object detection system: correctness and stability. Correctness is the obvious ability that we desire from any algorithm, the ability to produce results that are consistent with ground truth. Thus correctness is measured by the size of the NPR index.

The following table gives a comparison of the segmentation methods discussed. The parameters considered for the comparison are random in nature to aid the comparison between the approaches used. The corresponding entries are based on the observation of the result images shown above in discussion. We require segmentations with low bias and low variance. There are two basic types of stability, stability with respect to parameters and stability across images. Stability with respect to parameters refers to achieving consistent results on the same image given different parameter inputs to the algorithm. in other words, we would like the algorithm to have low variability with respect to its parameters. Stability across images refers to achieving consistent results on different images given the same set of parameters. if a segmentation algorithm can be shown to be both correct and stable, then it will be a useful preprocessing step for many systems.

V. DISCUSSION & CONCLUSION

Image segmentation is a process of dividing an image into its constituent homogeneous regions

to extract data from the attributes of the image. As a result, a good segmentation should result in regions in which the image elements should have uniform properties in terms of brightness, color or texture etc. The segmentation process can be divided into various category based on the parameter selected for segmentation like pixel intensity, homogeneity, discontinuity, cluster data, topology etc. Each approach has its own advantages and disadvantages. The result obtained using one approach may not be the same as compared with other approach. Methods that are specialized to particular applications can often achieve better performance and this selection of an appropriate approach to a segmentation problem can be a difficult dilemma.

So a single approach to segment all variety of images may be practical unachievable. The prior knowledge on the image can give better results and gives user the choice to decide proper method to segment the image.

Image Segmentation Methods:

A Comparative Study

Parameter	**Threshold Based Segmentation**	**Edge Based Segmentation**	**Region Based Segmentation**
Nature of the Output image	Black-White	Black-White	Black-White
Spatial information	Neglected	Neglected	Considered
Region-Continuity	Moderate	Moderate	High
Computation Complexity	Less	Moderate	High
Speed	Fast	Moderate	Slow
Noise immunity	Less	Less	Less
Detection of Multiple objects	Poor	Poor	Moderate
Automaticity	interactive (Semi-Automatic)	interactive	interactive (Semi-Automatic)
Accuracy	Moderate	Moderate	Good

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