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Target Seg: A GUI for Image Segmentation using Morphogical Watershed and Graph cut Techniques

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Abstract

The aim of this paper is to develop an efficient and a powerful Matlab based graphical user interface to address the problem of image segmentation. We propose two approaches for segmenting images: An automatic marker controlled watershed segmentation for segmenting an entire image or a scene and a semiautomatic graph cut based segmentation using fixation points. Automatic Watershed segmentation with a Sobel edge detector is used to detect the gradient of an input image resulting in an image less sensitive to noise. To deal with the usual problem of over segmentation using watershed, marker controlled watershed transformation is applied further for segmenting an image. Fixation based graph cut segmentation allows the user to analyze the input image displayed on the screen and specify some hard constraints indicating the object of interest or target object by using the mouse interaction. Experiments are done on the publically available dataset and the results of the supervised evaluation methods are observed to be satisfactory and are demonstrated along with the manually segmented reference image or a ground truth image obtained from segmentation evaluation database

Keywords*: Graph cuts, interactive image segmentation, maxflow/mincut, energy function, marker controlled transformation, Sobel edge detector*

1. Introduction

Segmentation in image and video processing is most important and fundamental step in higher level image processing application involving object detection, tracking and recognition. Segmentation is defined as the process of dividing the image in spatial domain to number of regions or segments. These regions further correspond to a part of an object or a whole object itself .The problem of image and video segmentation renewed a great attention to the researchers as it is a mathematically ill-posed and psycho-physical problem. Extensive research has been carried out in the area of image and video segmentation and several algorithms and techniques are developed: Thresholding, Edge detection, Region growing methods, clustering methods, and compression based methods, Watershed transformations, Morphogical methods, Graph partitioning methods etc. The performance of the image and video segmentation algorithms is judged mainly on how well the region is segmented.ie segmented region or object or part of the object has a meaning associated with itself or with in a scene. Generally there exists no segmentation algorithm which can be commonly applied on all the domains. Segmentation algorithms are adhoc in nature and either user has to develop a segmentation algorithm w.r.t domain related problem or make a choice among the existing algorithm and then apply one or

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more segmentation algorithm to the problem. The outline of the research paper is organized as follows: Section2 introduces to the previous work related to image segmentation.Section3 discusses about fixation based graph cut image segmentation, some basic definitions, notation used in graph cut and also the role of graph theory in image segmentation.Section4 presents marker controlled watershed transformation for segmentation and demonstrates the results.Section5 describes the proposed GUI for image segmentation using graph cut and watershed transformation. The results of the relative evaluation methods are illustrated in section 6 and section7 finally draws the concluding remarks of the paper.

2. Related Work

An iterative Graph cut based image segmentation is proposed by Greg Slabaugh and Gozde Unal [1] using the shape prior cue and thus eliminating noise and weaker boundaries. Their contribution to the field of computer vision highlights on segmentation of human faces and magnetic resonance images. The results obtained after the partition process are highly efficient and robust and hence can be further used in high level image processing tasks.

Yuri Boykin, Olga Veksler, Ramin Zabih [2] proposed algorithms for segmentation of images using graph cuts. Their work mainly focused on minimizing the energy used in the partition of an image. The energy function is designed and developed with two algorithms: swap and move method and expansion and move method .The results thus obtained are good when compared with simulated annealing and other techniques.

Boykov, Yuri Y, and Marie-Pierre Jolly [3] proposed a technique for the segmentation of N-dimensional images based on boundary and region information. The interactive method allows the user to specify the object of interest as either the "foreground" or the "background" and finds an optimal solution using Max-flow algorithm in graph theory.

Rosen, Evan, and Nikil Viswanathan [4] address the problem of segmentation using grab cut algorithm and develop an efficient and robust tool for automatic segmentation of images termed as Auto cut. Unlike the other interactive graph cut methods, the proposed technique does not require a user to specify any prior information about the foreground object that has to be segmented .Auto tuning with a minimum number of parameters is applied and a bounding box is dynamically selected over the foreground region.

In the past mathematical Morphogical operations with a combination of traditional background subtraction technique are used in the most of the surveillance and tracking applications in computer vision. But these methods suffer from a serious problem around the edges or boundary of an image especially in case of noisy images which are most common in real time. The solution to such problems is addressed by Howe, Nicholas R., and Alexandra Deschamps [5] by applying most popular Maxflow/Min-cut algorithm in graph theory. The segmented foreground object thus obtained is more accurate with smooth boundary.

Zhang, Zhen [6] proposed hierarchical framework for the segmentation of the image at the object level. The framework consisted of four different stages: coarse level segmentation, fine level segmentation, the combined coarse and fine level segmentation resulting in an patch level saliency map. In the final stage heat diffusion method is applied to produce an object level saliency map and differentiate between different object regions. Low level image cues such as shape, color, texture, contour, spectral attributes and the shortest distance between two edges in a graph are used in defining the feature vector space with a Gaussian mixture model.

Further potts variational model is applied on the feature vector to partition the input image at the fine level and a heuristic approach decides the level of partition process [6, 7].

3. Fixation based Graph cut Image Segmentation

Interactive image segmentation method facilitates the user to give some level of input as a cue for segmentation process i.e. It allows the user to specify the object of interest as either the foreground or the background by using the fixation points. Fixations are usually a mouse click in case of semi automatic tool or automatically select the region to be segmented in the case of automatic tool for segmentation. Sadeghi, Maryam [7] proposed an interactive GUI based on eye gaze where in the user just looks at the GUI screen and does the fixations of the seed pixel specifying the object of interest to be segmented. Once the object of interest is specified with a hands free procedure Random walk algorithm for image segmentation and eye gaze controlled method demonstrated better performance in terms of speed when compared with mouse controlled method. A semi-automatic segmentation technique using graph cut algorithm with the prior shape cue is proposed by Dainel Freedman & Tao Zhang [8] and the analysis provided good results on both the medical images as well as the natural images.

3.1 Graph Theory in Image Segmentation

Graph theory is the mathematical model used to study the relation between a pair of objects from a specific dataset. To give more details about graph based image segmentation, we discuss some of the terminologies and definitions used in our work. Let G be a graph ,where G=(V,E) V representing a set of vertices {v1,v2,v3,v4,v5……vn} and E representing the set of edges{e1,e2,e3,e4,e5….en}respectively. Let(vm,vn) corresponds to weight w.r.t edge (vm,vn).In the graph theory model, based on the degree of dissimilar edges, the graph can be divided into set M and N which are disjoint in nature .Similarly the concept of graph cut is extended to image segmentation where the cut in a graph is usually defined as

$$\mathbf{Cut\ (M, N) = \Sigma\ W\ (u, v)} \quad \text{---------- (eq-1)}$$

Where u and v refer to the vertices in two different components M and N respectively. Cut (M, N) in a graph G is a set of edges Ecut such that there is no path from source to sink when Ecut is removed from G thus specifying the minimal solution. The sum of all the edges in Ecut gives the cost.

Many researchers in the past contributed their work towards providing a global optimal solution for a low level image processing tasks such as image smoothing, image segmentation, image enhancement, image restoration, texture object reconstruction [11].The main idea behind using graph cut in image segmentation is to define cost function such that it utilizes minimum energy to segment an image in to different segments or parts. Maxflow/Min-cut algorithm is most commonly used in the graph cut models for providing minimal cuts and normalized cuts in the graph. Simulated annealing german brothers, conditional modes, and other greedy algorithms by Julian besag [11] were being used before graph cut. D.M. Greig, B.T. Porteous and A.H. Seheult first introduced the graph cut in the field of image processing for image smoothing [11]. The problem of image segmentation is studied in terms of Maxflow/Mincut graph theoretical algorithm. It states that the maximum value of the flow from the source to sink is equal to the minimal cost from source to sink of a Cut (M, N).

4. Watershed Image Segmentation

In Computer vision and Image processing watershed is having number of definitions and there exist many algorithms like Meyers' flooding algorithm, watershed cuts based on optimal spanning tree forest for computation of watershed.

Image Segmentation is the main goal of all the watershed algorithms. Let us define watershed and catchment basin w.r.t geography. The ridge that separates' drained areas from different river system is referred to as Watershed. The geographical area draining into a river or reservoir is referred to as catchment basin.

The principle of watershed image segmentation is based on either of the two approaches as below:

1. Choose the marker based on local minima of a gradient image.
2. Specify the marker based on the user input or automatically find the marker based on Morphogical operators.

The results of watershed image segmentation are illustrated from the Figure 1 to Figure 11.

Figure 1. Input Red Berry Image

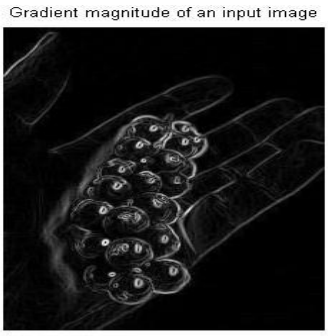

Figure 2. Gradient Magnitude

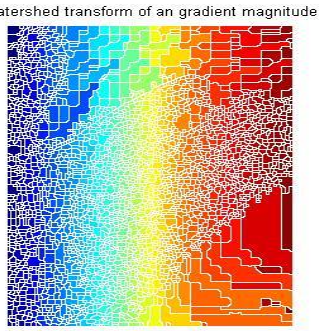

Figure 3. Watershed Transform

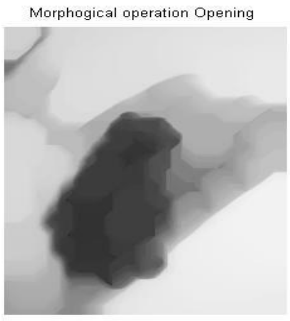

Figure 4. Morphogical Opening Operation

Figure 5. Morphogical Opening by Reconstruction

Figure 6. Morphogical Opening-Closing by Reconstruction

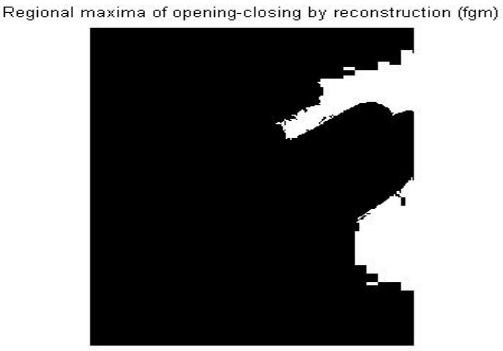

Figure 7 Regional Maxima Opening-Closing by Reconstruction

Figure 8. Regional Maxima Superimposed on Original Image (fbm4)

Figure 9. Modified Regional image Superimposed on the Original Image

Figure 10. Threshold Opening-Closing by Reconstruction

Figure 11. Markers and Object Boundaries Superimposed on Original Image

5. Target Image Segmentation

There has been a tremendous progress in the area related to the design of semi automatic segmentation tools and automatic segmentation tools. Automatic Segmentation tools often require high level or global knowledge about the region or object or part of the object to be segmented with little or no user interaction. Generally the task of automatic segmentation is complex, hard, and less accurate and requires more computation time as the cue processing has to take place dynamically. On the other hand a semi-automatic segmentation tool allows the user to specify the input and produces precise and accurate results when compared with automatic segmentation. User can interact with the image and outline the region of interest by using either the keyboard or mouse. The snapshots of the Target Seg are shown in Figure 12-15.

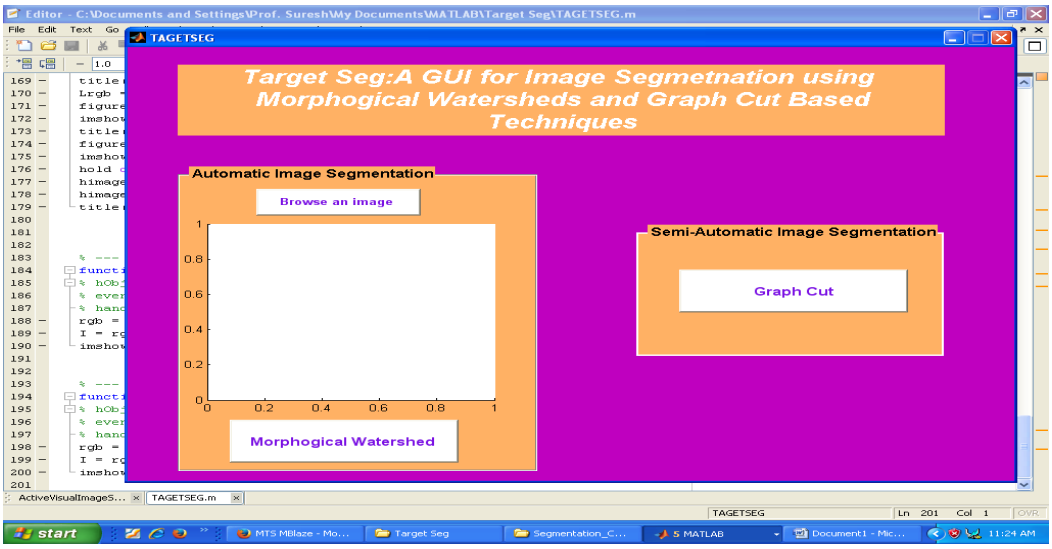

Figure 12. Snapshot 1

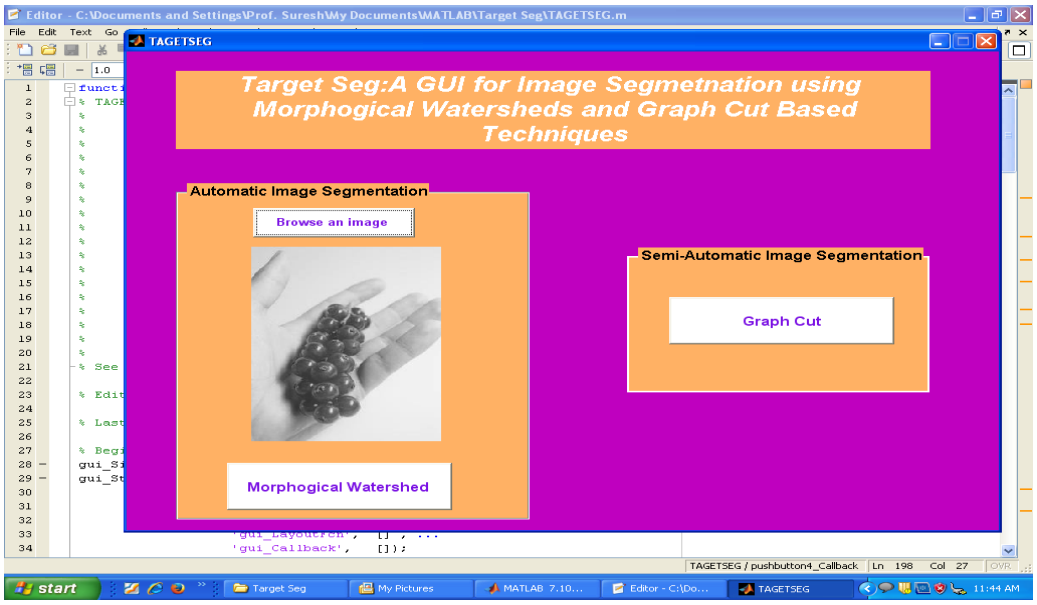

Figure 13. Snapshot 2

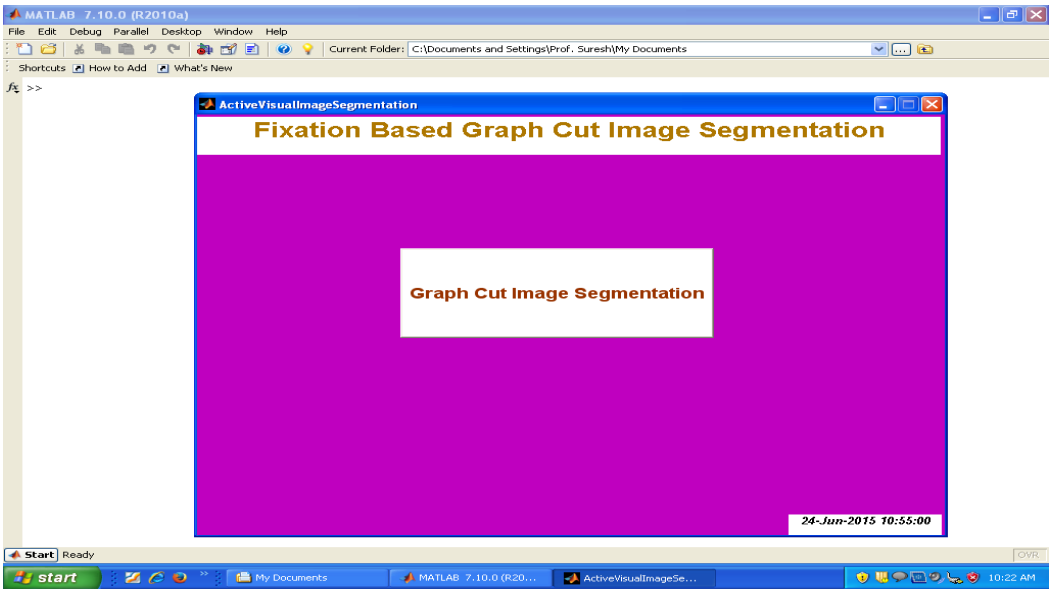

Figure 14. Snapshot 3

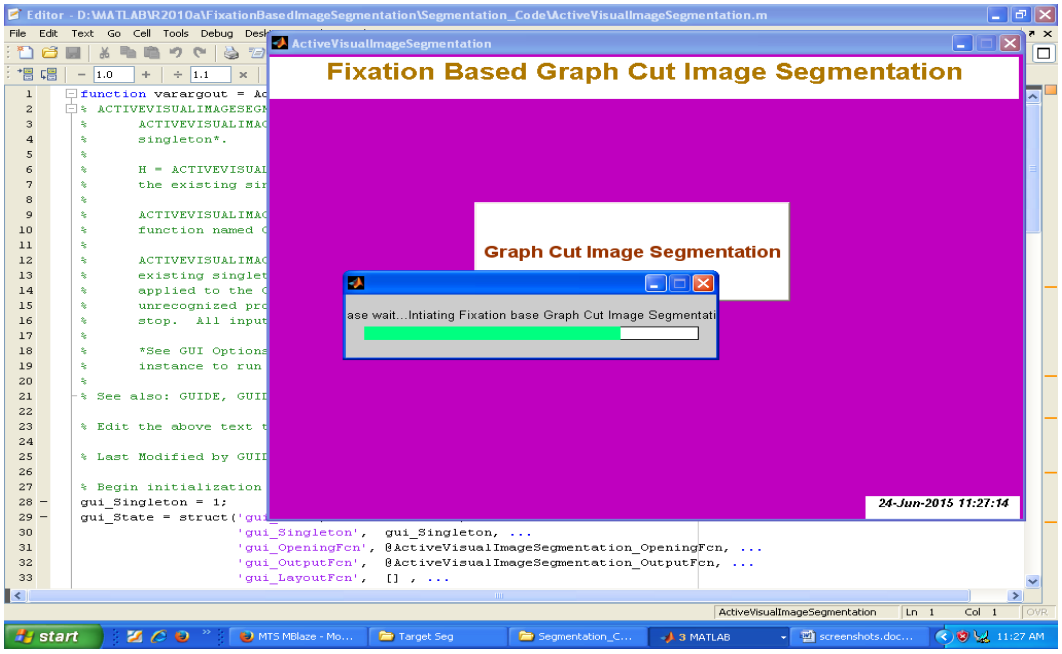

Figure 15. Snapshot 4

6. Results & Discussion

Figure 16. (a)Inputimage 1

Figure 16. (b) Groud Truth

Figure 16. (c) Fixation based Graphcut Segmentation

Figure 17. (a) Inputimage 2

Figure 17. (b)Groud Truth

Figure 17. (c) Fixation based Graphcut Segmentation

Figure 18. (a) Inputimage3

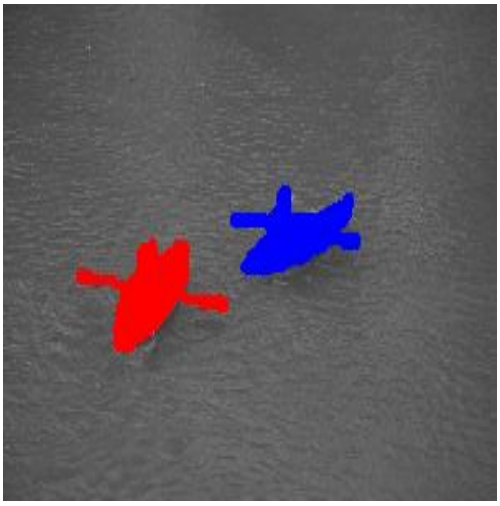

Figure 18. (b) Groud Truth

Figure 18. (c) Fixation based Graphcut Segmentation

In general the problem of segmenting an image yields to two prominent questions: Whether to segment an entire image or to segment only a part of the image (object of interest)? The former case of segmentation is not a well defined problem while the later is well defined. Let us understand this with an example input image 4 shown in Figure 19(a).The natural scene image consists of two prominent objects, say moon and tree. The segmentation, shown in the leftmost image Figure19(c) is correct, if the moon and tree both are of interest to the problem at hand. By the same logic, we can deduce that the segmentation shown in the rightmost image and is appropriate if the only moon is of interest. So, with this we can say appropriate segmentation of a scene is strongly linked with the object of interest in the scene and should be identified even before the segmentation process begins. The proposed segmentation algorithm which takes a fixation point as its input and outputs the region containing the given fixation point in the scene. For example, for the two fixations points, indicated by the mouse clicks, on two different objects (see Figure 19(a)) our method segments the corresponding regions enclosing those fixations points (see Figure 19.(c) & Figure 19(d)) .

Figure 19. (a) Inputimage 4

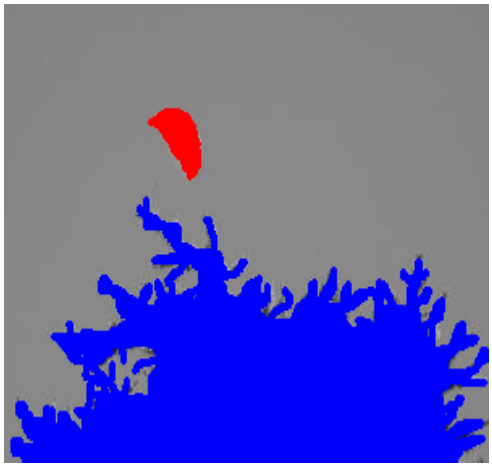

Figure 19. (b) Groud Truth

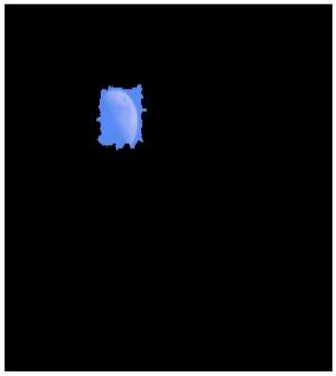

Figure 19. (c)Graph Cut Segmentation with Moon

Figure 19. (d) Graphcut Segmentation and Tree as Target Object with Moon as Target Object

After selecting fixation points in an input image with two different fixations and segmented using fixation based graphcut technique as shown in (c) and (d) ,the energy computation by successive iterations in both the cases respectively is given the table 1:Energy Computation.Finally the answer to the two questions possed in the beginging of this section is it all depends on the application in hand.

Table 1. Energy Computation

Iterations	Energy	Energy
	Target object segmentation with fixation points Tree and Moon	Target object segmentation with fixation points Moon
Iteration - 1	22468.907821	247.983392
Iteration - 2	19900.812119	174.859325
Iteration - 3	19185.183948	167.563870
Iteration - 4	19043.910365	164.778060
Iteration - 5	19015.985138	158.849649
Iteration - 6	19004.507845	158.849649
Iteration - 7	19001.657711	158.849649
Iteration - 8	19000.842227	158.849649
Iteration - 9	18999.499134	158.849649
Iteration - 10	18996.320931	158.849649
Iteration - 11	18991.189352	158.849649
Iteration - 12	18986.766915	158.849649

7. Conclusion

We propose a new graphical user interface using marker controlled watershed for automatic image segmentation and maxflow/mincut graph theory related algorithm for semiautomatic target image segmentation resulting in qualitatively and quantitatively

cleaner results. Fixation base graph cut segmentation made the problem of general segmentation easier, efficient and robust with fewer hard constraints specify by user. The supervised evaluation study with two techniques gave a new dimension to the classical definition of segmentation as partitioning an entire image /scene into different regions to a newer definition of partitioning only the fixated region. The results of the user experiments on TargetSeg GUI are demonstrated and compared with manual segmentation obtained from the publicly available segmentation evaluation database.

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