Graph Cut Based Multiple Interactive Image Segmentation for Medical Applications

[1]Mamatha S K, [2]Krishnappa H K
[1]Assistant Professor, [2]Associate Professor
[1]Dr.Ambedkar Institute of Technology,Bangalore,
[2]RVCE, Bangalore

Abstract - **Segmentation of medical images could be a basic and difficult task in the field of medical applications. There are several existing medical image segmentation approaches, among these existing graph cut methods are comparatively new and has good features in medical applications. Segmenting clinical images could be effortful, long method, slow process and automatic image segmentation method typically contain errors and imperfections. Interactive image segmentation is associate rising technology within the areas of image processing, computer vision and medical field. Graph cut based Multiple interactive segmentation is presented is in three steps. Initially, nodes representing pixels of image area connected to their k-nearest neighbors to cover foreground image. Within the second step, energy function of graph is employed to improve the segmentation on the object borders to hide background information set. Third step extracting user interacted object from image set. This paper also investigated issues of previous methods like mean shift segmentation, watershed technique and automatic graph cut based image segmentation. As a result, the graph cut method cut method shows higher performance than previous methods.**

keywords - **Interactive segmentation, Automatic graph cut, Mean shift segmentation**

I. INTRODUCTION

Interactive segmentation could be a quickly growing space of computer vision and has seen heightened interest recently [6]. Whereas ancient segmentation seeks to spot object and structures inside a picture of data in an exceedingly automatic fashion, Interactive segmentation, one kind of active learning [9], accomplishes the goal of image segmentation whereas incorporating a wide range of user interactions in that area of medical field enclosed as further constraints or steerage within the segmentation model. This interaction might contest completely different forms, and will embrace drawing a bounding box, roughly outlining a boundary [8], or drawing brush strokes with in and/or outside the article of interest. A desired property of interactive segmentation approach is that the user interaction be as convenient (i.e., low psychological feature load) and thin (i.e., few in number) as attainable, whereas at the same time providing immediate feedback to the user on each interaction.

One domain that has been unaddressed in interactive segmentation literature is medical oriented science image segmentation for medical image applications, wherever their existing techniques focusing exclusively on medical images victimization an interactive approach. Recently a graph cuts methodology has more attention and advantages in segmentation of medical applications. The graph cut method is one of minimizing energy functions elegantly expressed as MRF (Markov Random Field), and also the energy perform consists of 2 terms; primary term, known as information term, is to globally capture the characteristics of a picture in feature area, and also the second term, known as smoothness term, is to preserve special data in a picture domain [1]. Thus, the graph cuts-based approach will mix on top of mentioned 2 approaches, cluster in feature area and protective special relationship in image domain [7]. Image segmentation is an especially vital operation in many applications of image process and computer vision like object trailing, recognition, restorations of Image and video compression could be a vital step of image analysis occupying the center layer of image engineering, which implies it's influenced not solely from information however the conjointly from human factors [2].

There are several current medical image segmentation methodologies: Threshold image method [6]–[10], Region growing methodology, Edge detection methodology [13]. At the side of these ancient technologies, there open area measure numerous advanced approaches, together with model-based ways, partial differential equations (PDE)-based ways, and graph-based ways. The representatives in model-based cluster square measure active form models (ASM) [11] and active look models (AAM) [3]–[7]. The ASM/AAM ways use "landmarks" to represent form and principal element analysis (PCA) to capture the most important modes of variation in form discovered within the coaching datasets. In PDE-based ways, level sets square measure a vital class of techniques [5]–[7].

Among all graph cut based methods mostly segmentation ways, GCs square measure comparatively new and arguably the foremost powerful mechanisms [54]. A detail discussion and comparison of those segmentation methods is found in. The graph construction section share some similarities there with planned by diacritic (2017). However, that approach uses ineffective and un-weighted graph whereas this study uses weighted digraphs.

II. MULTIPLE INTERACTIVE IMAGE SEGMENTATION

In developed multiple interactive image segmentation method, multiple user interaction is allowed on input image to be segment for some medical diagnosis in order to treat the patient. In this method split the image into number regions of interest so that user can able to propagating segmentation of region on object. Regions are consider as a slice unit (SU) corresponding to each

interaction of user on object of interest. Each slice SU to a neighboring slice SU1, distance is measured in to cover the region of interest, resulting in a segmentation of SU of the image. This way, using an initial segmentation on one slice unit, we can repeatedly propagate this segmentation to the remaining slices in the volume to obtain completed border segmentation. This propagation was done while creating and drawing an interaction on the input image, though which the topology of the given object to be preserved, which led to a better presentation when compared with methods that did not incorporate topology as a prior.

Specifically, let the segmentation of slice unit SU = {SU1, SU2, ..., SUn}, where SUi, i = 1 ... n are disjoint segments in slice unit SU, and this collection of interaction is called multiple interaction, so this repeated interaction helps, to perform better segmentation with this kind to makes up a partition of the slice unit SU. Number of regions that covers slice unit is calculated as,

$$N(r) = \sum_{i=1}^{n} SUi$$

Where all the interaction lines ("small piece" structures) are separated by some color lines. To propagate segmentation SU to a new slice unit SU1 to yield the segmentation off object.

Minimize the energy,

$$E(SU) = \sum_{p \in v} p(SUi) + \sum_{\{p,q\} \in pv} pq\,(SUi, SUj) \qquad (1)$$

Where pv is the set of all connected pixels in SU. The unary term p(SUi), which represents a probability of each slice unit length for a pixel P being assigned to a segmentation of SUi in slice neighbor SU1, was set to replicate the structure continuity between two pixel in input image set,

$$p(SUi) = \begin{cases} 0, & \text{distance}(p, SUi) < \text{distance}(d) \\ \infty, & \text{otherwise} \end{cases} \qquad (2)$$

Where d is a dilation distance that reflects the maximum possible structural change between two neighbor pixels U1 and U2. In addition, the binary term pq (SUi, SUj), which represents a distance intensity for a pair of neighboring pixels p, q being assigned to two (possibly the same) segments SUi, SUj, was restricted to preserve non adjacency segment relationships from two different slice units; i.e., any two segments SUi, SUj are allowed to be adjacent (have pixels that are all-connected between each other) only if the corresponding segments SUi, SUj are also adjacent.

III. PREVIOUS APPROACHES

A. Mean shift method

It is a non-parametric feature-space analysis technique, a so-called mode seeking algorithm. Mean shift is a procedure for locating the maxima of a density function given discrete data sampled from that function. It is useful for detecting the modes of this density. This is an iterative method, and we start with an initial estimate x.

Let a kernel function k(x1-x2) be given. This function determines the weight of nearby points for re-estimation of the mean [10]. Typically Gaussian kernel on the distance to the current estimate is used, k(x1-x2) = $_e$c||xi-x||2 weighted mean of the density in the window determined by k is:

$$m(x) = \frac{\sum_{x_i \in N(x)} K(x_i - x) x_i}{\sum_{x_i \in N(x)} K(x_i - x)}$$

Where m(x) is the neighborhood of x, a group of points that k(x) ≠ zero. The Mean Shift (MS) algorithmic program could be a strong feature space analysis approach which may be applied to separation, conserving, smoothing and image segmentation issues. It will considerably cut back the amount of basic image entities, and thanks to the nice separation conserving filtering characteristic, the salient options of the image area unit preserved. The latter property is especially vital within the partitioning of natural pictures, during which solely many distinct regions area are employed in representing completely different scenes such as sky, lake, sand, beach, person, and animal, where different info at intervals a locality is commonly reduced and may be neglected. However, it's troublesome to partition a natural image into suggestive regions to represent distinct scenes, relying solely on the MS segmentation algorithmic program. The most reason is that the MS algorithmic program is associated in unsupervised clustering-based segmentation technique, wherever the amount and also the form of the info cluster area unit unknown a priori.

Moreover, the execution of the segmentation method relies on some region-merging strategy applied to the filtered image result, and also the variety of regions within the divided image is especially determined by the minimum variety of pixels in a very region, that is denoted as M (i.e. regions containing but M pixels are going to be eliminated and unified into its neighboring region) [10]. Mean Shift is taken into account a robust technique used for image segmentation, visual compression,

reconstruction etc. Mean shift methodology is associate reiterative mode detection formula within the density distribution area or a tool for locating modes in a very set of knowledge samples.

B. Watershed Technique

A grey-level image could also be seen as a topographical relief, wherever the gray level of a picture element is taken as its altitude within the relief. A drop of water falling on a topographical relief flows on a path to finally reach an area minimum. Intuitively, the watershed of a relief corresponds to the boundaries of the adjacent structure basins of the drops of water. In image process, totally different watershed lines could also be computed. In graphs, some could also be outlined on the nodes, on the sides, or hybrid lines on each nodes and edges. Watersheds might also be outlined within the continuous domain. There are many alternative algorithms to calculate watersheds. For a segmentation purpose, the gradient magnitude (i.e., the length of the gradient vectors) is taken as altitude info [12]. In earth science, watershed suggests that the ridge that divides areas drained by totally different water course systems. If image is viewed as geologic landscape, the watershed lines verify boundaries that separate image regions. The watershed rework computes structure basins and structure basins such as image regions and ridgelines with reference to region boundaries [13]. Segmentation by watershed embodies several of the ideas of the three techniques like threshold based, edge primarily based and region based segmentation.

C. Graph Cut Method

Image segmentation based on graph cut method basically relates background and object to be segment, which can be employed as binary graph labelling problem. Boykov et al. [14] mentioned the segmentation of a monochrome image that solves a two labels problem in the graph cut method. Considering a set of labels *L* and a set of spots *S*, the labelling problem can be assigned as a label fp∈ L and each of the spot p∈S. The label set L= {0, 1} where 0 indicates background and 1 indicates object.

For a labelling problem if f = fp | fp ∈ L for all pixels, the energy minimization Markov Random Field (MRF) equation [10] can be written as:

$$E(f) = \sum_{p \in S} D_p f_p + \lambda \sum_{(p,q) \in N} w(pq).T(f_p \neq f_q) \quad (2)$$

In the energy minimization equation, the first term called as numbers (data) term consists of constraints from the observed data and measures how the labels are assigned based on this data. Label fp fits with spot p and is measured by Dp. The second term the smoothness is measured to the extent of function fp, which is overall smoothness of image.

If fp = fp, T(f ≠ f) becomes 0 and 1 otherwise. In image segmentation boundary value to taken from selection of edges from different angle, so that the boundary to be positioned on the edges. Hence the typical selection of edge weight becomes:

$$W_{pq} = \frac{e^{(I_p - I_q)^2}}{2\delta^2} \frac{1}{dist(p,q)}$$

Color values of spots p and q are represented by *Cp* and *Cq* along with distance between p and q is presented by *D(p,q)*. The data term and smoothness term have relative importance in terms of its parameter specified by both terms with respect to background and foreground data sets [12].

Graph cuts method has drawn a lot of awareness for image segmentation of medical images in order to diagnose the diseases. The graph cuts method is one of minimizing energy functions elegantly expressed as MRF (Markov random field), Such energy minimizations problems with respect to nodes representing pixel of image can be reduced to each instances of the maximum flow problem in a directed graph (and thus, by the max-flow min-cut theorem, define a minimal cut of the graph). Under most formulations of such problems in computer vision, the minimum energy solution corresponds to the maximum a posterior estimate of a solution. Although many computer vision algorithms involve graph cutting methods (e.g. normalized cuts, equivalent cut), the term "graph cuts" is applied specifically to those models which employ a max-flow/min-cut optimization techniques in various algorithms.

In the Bayesian statistical context of smoothing noisy (or corrupted) images, an idea has implemented. That gives an information about how to deal with the maximum a posterior estimate of a binary image can be obtained exactly by minimum cut and maximum flow through an associated image network, involving the introduction of a source and sink nodes to connect all the other nodes in the graph, using min cut max flow algorithm [8].

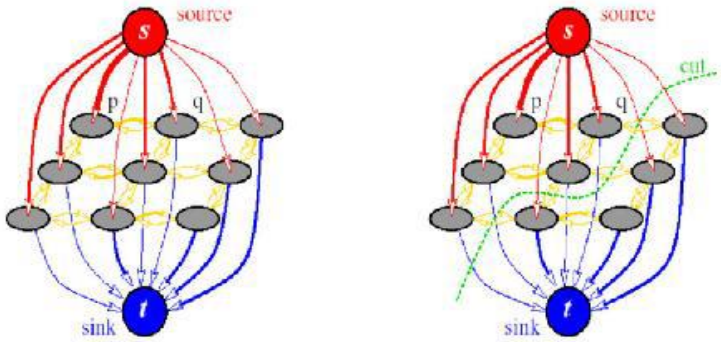

Fig.1: Graph cut for image segmentation (source and sink) [8]

IV. COMPARISON AND RESULTS

To verify the effectiveness of the proposed graph cut method, with three methods which have been discuss, quantitative evaluation to be performed. For These three methods quantitative evaluation was tested with natural color and the real MRI brain images. Later this comparison table can be used to check the result of multiple interactive segmentation method after the implementation of this method. The performance of image segmentation on the test set was evaluated in terms of visually and the subjective parameters such as PSNR, MSE and the computational TIME.

Table1. Shows list the PSNR, MSE and TIME on the test set of Mean shift, Watershed, Graph cut methods [5].

Image	Segmentation Tech.	PSNR	MSE	COMPUTATIONAL TIME
Image 1	Mean shift	8.499	949	4.30
	Watershed	26	162	1.8
	Graph cut	26.9	147	5.3
Image 2	Mean shift	14.23	230	3.88
	Watershed	27.9	125	1.6
	Graph cut	65	120	3.7

Results of Mean shift, Watershed, Adjacent graph cut methods have taken to analyse the way of interactive segmentation is better on various image set of medical field.

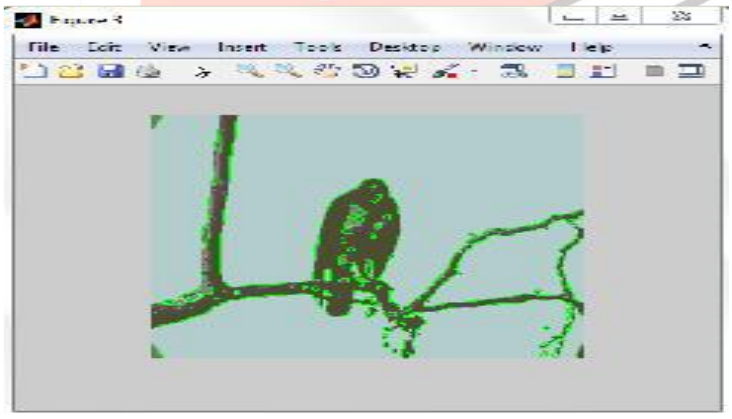

Fig. 2: Shows result for mean shift [8]

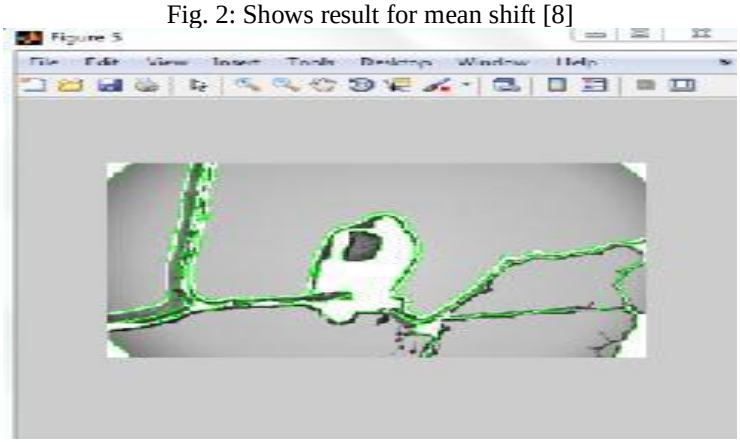

Fig. 3: Shows result for Watershed [8]

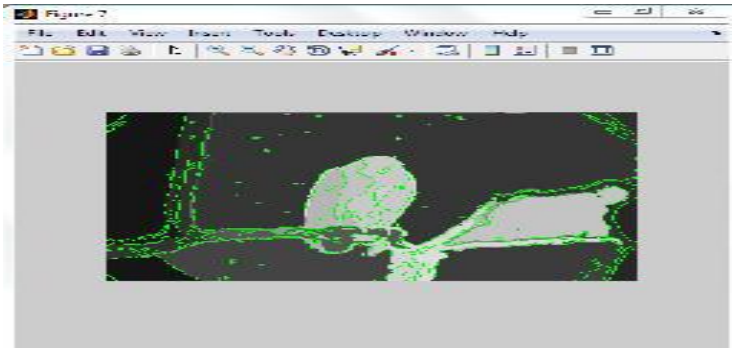

Fig. 4: Shows result for adjacent Graph cut [8]

CONCLUSION

Graph cut based multiple interactive segmentation methodology is used in various field of medical application. Results obtained from Mean shift, Watershed, Graph cut methods would be used to compare and show that the multiple interactive segmentation method is capable of accurately segmenting any of the uninformed shapes at the rate of computational time. Also this method overcomes the problems from the graph cut using mean shift, watershed approaches. This technique is evaluated for segmenting the MRI images to find brain tissues and other brain element and as well for mammogram images. Finally as a result, the graph cut based multiple interactive method shows higher performance than previous methods.

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