Recent Trends in Medical Image Segmetation: A Comprehensive Survey

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***Abstract*— Image segmentation is one of the important steps in the field of medical imaging where computer technology is used to detect and locate the anatomical structures in the body parts of human beings. A lot of work has been done in this regard in the past three decades. With the advancement of image acquisition techniques there is a need to develop more efficient and reliable segmentation technique to delineate the abnormal structure. In this paper we present recent developments in the field of image segmentation and analyse various segmenting techniques and their suitability in medical imaging where images are very complex and it is very difficult to define exact boundaries of the normal and abnormal tissues.**

Keywords-Medical Images, Segmentation, MRI, Watershed, Level Set

I. INTRODUCTION

Segmenting an image means to separate the object of interest from rest of the image. Image segmentation is one of the most imperative steps in image processing. In image processing scenario image segmentation is needed when we want to study a particular object from an image rather than whole image. As we know image processing involves the use of computer technology to analyze the computer generated images called digital images. Image processing is used in several fields such as satellite imaging, oceanography and medical imaging etc.

As far as medical imaging is concerned, image segmentation has a vital role to play. In the field of cancer research, diagnosis of cancer required detection of tumor at early stage. According to a report from a cancer research organization, in 70% to 80% of cancer cases, tumor at early stages remains undetected. This is mainly due poor image acquisition method. Now a days there are so many robust methods have been invented like MRI in which anatomical structure can be clearly seen by naked eye. In MRI images abnormal structure can be easily seen but still radiologist find difficulty to manually define actual boundaries of the normal and abnormal tissues due to overlapping between them. As the proper diagnosis of cancer requires delineation the actual boundary between healthy and cancerous tissues, there is a need to develop an automated segmentation technique which not only segment the tumor but also define the actual area as well as its actual location.

II. SURVEY OUTLINE

This comparative study includes several fundamental segmentation techniques that are widely used in the area of computer vision and medical imaging. It also includes recent development over the last ten years that are based on these techniques. In particular, this survey focuses on the specific techniques that are most suitable for medical imaging.
Depending upon the area of application segmentation can be broadly classified into three categories according to the image characteristics being used: boundary based, region based and hybrid. Typically region based and boundary based techniques exploit within region similarities and differences while hybrid methods use both region based and boundary based features.

III. COMPREHENSIVE STUDY

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A. Edge Based Methods

In edge based approach a predefined threshold value is chosen and this threshold determines which pixel values are separated from rest of the pixel values. Since these methods use threshold value these are not suitable for those images where

images are less homogeneous. Moreover it is very difficult to choose the appropriate threshold for segmentation. The first one was proposed by chan and vase [1] in which segmentation process starts with the evolution of a curve. This curve is evolved by minimizing the energy function of zero level set [2]. Curve evolution starts moving towards the interior normal and has to stop at the boundary of the object. Though it is quite useful in some applications of image processing, it is unsuitable for medical imaging. As it does not used gradient edges of the image, it cannot detect weak edges from the image, so its unsuitability for detecting tumors from medical images.

Another segmentation approach is vector quantization [4] which is based on clustering. In this technique a codebook is generated for each image. A codebook represents a specific pattern of pixels where each different pixel pattern represents different objects in the image. The clustering of these types of patterns is generated by various VQ algorithms. This technique is effective where there is no overlapping of pixels of different tissues. As in case of medical images overlapping may occur due to dynamic nature of harmful tissues which travels from one part to another part. So this technique is not useful for detecting brain tumors.

Gaussian Mixture models [6] are also applied to segment an image. Gaussian Mixture Models (GMMs) have interesting properties that make them useful for many different image applications because they have powerful probabilistic statistical theory basis. However, the application of GMMs to medical image segmentation faces some difficulties. First, many typical model selection criterions become invalid when they estimate the number of components of medical images. Second, the convergence function of GMMs suffers slow convergence.

Another improved edge base adaptive snake method [9] is widely used in ultrasonic medical images. First, the image is decomposed in the place which has offset from pixel's position while snake points are in pixel's position. This will reduce the task during calculating intersections between contour and ACID grid. Second, the rule to process topology conflict is simplified and there is no need to judge triangle point in or out of the contour in this model. Third, since ultrasound image has a lot of speckle noise, external energy is composed by three parts-the gradient-based image energy, the inflation energy and region based image energy, which can push T-snake into the real edge.

B. Region Based Methods

Another approach which we are discussing is region based where region of interest is grown depending upon the similarities between neighbouring pixel values. Region based techniques are more stout than edge based techniques as it does not use any edge information. In region based techniques a homogeneity predicate is used which add a intensity value of neighbour pixel thereby creating a separate region of pixels having same intensity values. Region based methods are more robust as they do not use any threshold. Moreover they also preserve the boundary values.

A shape analysis strategy termed "break-and-repair" is presented to facilitate automated medical image segmentation [10]. Similar to surface approximation using a limited number of control points, the basic idea is to remove problematic regions and then estimate a smooth and complete surface shape by representing the remaining regions with high fidelity as an implicit function. The innovation of this shape analysis strategy is the capability of solving challenging medical image segmentation problems in a unified framework, regardless of the variability of anatomical structures in question. In its implementation, principal curvature analysis is used to identify and remove the problematic regions and radial basis function (RBF) based implicit surface fitting is used to achieve a closed (or complete) surface boundary. This method uses curvature analysis to differentiate the shapes of objects. As curvature analysis can differentiate only three types of object shape viz. Lines, sphere and cylinder. This method can only be used to segment regular structures but structure of tumors is not always regular so this technique cannot perform better for irregular structures.

Watershed [11] is another efficient region based method which has gained popularity in the field of medical imaging due to its robustness of detecting continuous boundary of the segmented area of object. This method is also computationally efficient and required less human intervention when segmenting the objects. Although this method has the ability to accurately delineate the boundaries of the objects from the image, it suffers the problem of oversegmentation which is an undesired outcome from this technique. To overcome this drawback watershed technique must be combined with some other methods to get good results.

C. Hybrid Methods

With the advancement of computer technology and image acquisition methods in recent years it become imperative to have robust segmentation method which should be automatic i.e. need less human intervention and accurate enough to segment the detrimental tissue with utmost precision. Several image segmentation methods have been developed for medical imaging.

To make best use of MRI or CT imaging so many hybrid method have been developed such as variational level set [5] methods which are improved versions of chan and vase model [1]. It uses an improved energy function to evolve curve with some morphological operations. These morphological operations are performed to remove some of the undesired objects from image and then use a threshold which helps contour to move towards object boundary. Although it has the ability to automatically evolve the curve towards the boundary of the object and effectively segment the object. But it very difficult to choose an appropriate threshold for the curve. So if threshold is not chosen accurately, results may be affected.

With the emergence of hybrid level methods, problems associating with intensity inhomogeneities are less sever.

Level sets are part of an important class of methods that utilize partial differential equations (PDEs) and have been extensively applied in image segmentation [7]. A kernel function in the level set formulation aids the suppression of noise in the extracted regions of interest and then guides the motion of the evolving contour for the detection of weak boundaries. The speed of curve evolution has been significantly improved with a resulting decrease in segmentation time compared with previous implementations of level sets, and are shown to be more effective than other approaches in coping with intensity inhomogeneities. The improved signed distance function which is used in contour evolution has made level set function more robust than other conventional segmentation methods

The power of watershed algorithm can be best described when used with some other methods. Jaydavappa and Murthy [12] combined watershed algorithm with GVF snake model to reduce the computational complexity, to improve the insensitiveness to noise, and capture range. Specifically, the image will be segmented firstly through watershed algorithm and then the edges produced will be the initial contour of GVF model. This enhances the tumor boundaries and tuning the regulating parameters of the GVF snake mode by coupling the smoothness of the edge map obtained due to watershed algorithm. The proposed method is compared with recent hybrid segmentation algorithm based on watershed and balloon snake.

D. Discussion

No single method can be capable of segmenting all the anatomical structures from a medical image. Some methods are more sensitive to noise and cannot be used in noise prone images. Some techniques are capable of giving good results but take considerable computational time. Some methods need more human involvement and some are automatic or semi-automatic. It is desired to develop an efficient segmentation method which is accurate enough to detect the exact boundaries of the anatomical structure within minimum computational time.

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