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A Review on Ultrasound Image Segmentation Techniques

Pooja Rani (M.Tech student)*, Rakesh Verma (Assistant Professor)*

***ECE Department, Hindu College of Engineering, Sonepat**

Abstract- **Segmentation remains a necessary step in medical imaging to obtain qualitative measurements such as the location of objects of interest as well as for quantitative measurements such as area, volume or the analysis of dynamic behavior of anatomical structures over time. Image segmentation is one of the earliest and most important stages of image processing and plays an important role in analysis of medical ultrasound images but ultrasound images have low level of contrast and are corrupted with strong speckle noise. Due to these effects, segmentation of ultrasound images is very challenging task. In this paper we have reviewed various ultrasound image segmentation techniques like active contour method, genetic algorithm, Otsu's method etc.**

Index Terms - **Segmentation, Ultrasound, Active Contour, Genetic Algorithm, Ultrasound Images**

I. INTRODUCTION

Image analysis usually refers to processing of images by computer with the goal of finding what objects are presented in an image. Image segmentation is the most critical task in automatic image analysis [1]. Ultrasound image segmentation is strongly influenced by the quality of data. There are characteristic artifacts which make the segmentation task complicated such as attenuation, speckle, shadows, and signal dropout; due to the orientation dependence of acquisition that can result in missing boundaries [4]. Ultrasound imaging or ultrasonography is an important diagnosis method in medical analysis. It is important to segment out cavities, different types of tissues and organs in the ultrasound image for effective and correct diagnosis [3]. Ultrasound image segmentation is a critical issue in medical image analysis and visualization [7].

The ultrasound imaging method is used in the medical practices, along with other imaging procedures such as X-Ray, CT, etc., for producing images of live tissue and for the purpose of clinical diagnosis. Since advantages of ultrasound imaging method such as: being less costly, portability of the device, safety of the imaging technique to the patient, and the less amount of real time required for imaging, it has been paid more attention than other imaging techniques[2].

Despite all these advantages, ultrasound images, because of characteristic flaws such as speckle noises, and artificial borders, have very low qualities that cause the processing of such images to run into complications and difficulties. Therefore, the implementation of many existing processing algorithms on these images yields no favorable outcomes [2].

Although development of image segmentation algorithms has drawn extensive and consistent attention, relatively little research has been done on segmentation evaluation. Most evaluation methods are either subjective, or tied to specific applications [9]. Some objective evaluation methods have been proposed, but the majority of these have been in the area of supervised objective evaluation, which are objective methods that require access to a ground truth reference i.e. a manually-segmented reference image. Conversely, the area of unsupervised objective evaluation, in which a quality score is based solely on the segmented image, i.e. it does not require comparison with a manually segmented reference image, has received little attention. The key advantage of unsupervised segmentation evaluation is that it does not require segmentations to be compared against a manually-segmented reference image. This advantage is indispensable to general-purpose segmentation applications, such as those embedded in real time systems, where a large variety of images with unknown content and no ground truth need to be segmented. The ability to evaluate segmentations independently of a manually-segmented reference image not only enables evaluation of any segmented image, but also enables the unique potential for self-tuning [9].

II. DIFFERENT METHODS OF IMAGE SEGMENTATION

Segmentation Algorithms mainly based on two basic properties:

A) Discontinuity (Edge based Approaches) : Based on abrupt change in Intensity
B) Similarity (Region based Approaches) : Similar according to predefined Criterion

A. EDGE BASED APPROACHES

Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp adjustment in intensity at the region boundaries. Edge detection techniques have therefore been used as the base of another segmentation technique.

B. REGION BASED APPROACHES

An edge based technique attempts to find the object boundaries and then locate the object itself by filling them in, a region based technique takes the opposite approach, by starting in the middle of an object and then "growing" outward until it meets the object boundaries.

III) OTSU's ALGORITHM

Segmentation using Otsu's thresholding method is based on region homogeneity which can be measured using variance. Otsu's method selects the threshold by minimizing the within-class variance or maximizing between-class variance [8]. The variance of the image with L gray levels is calculated from

$$\sigma^2 = \sum_{i=1}^{L} (i-\mu)^2 P(i) \, .$$

Where *P(i)* is the normalized frequency for each gray level value *i* and μ is the mean gray level value over the whole image and calculated as:

$$\mu = \frac{\sum_{i=1}^{L} iP(i)}{\sum_{i=1}^{L} P(i)} = \sum_{i=1}^{L} iP(i) \, .$$

The goal of thresholding is to convert a grayscale image into a binary image, separating an object's pixels from the background pixels. Otsu's method is formulated as a discriminant analysis. Statistics are calculated for the two classes of intensity values (foreground and background) that are separated by an intensity threshold. The criterion function is 2 / 2 *Bi T* for every intensity, i = 0,..,I-1, where 2*Bi* s is the between-class variance and s is the total variance and I = 256, the maximum of the intensity gray level. The intensity that maximizes this function is the optimal threshold [6].

IV) GENETIC ALGORITHM

The genetic algorithm is an efficient, adaptive and stable method of optimization which has caught the attention of the researchers in the last several years. However, these algorithms don't guarantee the optimum solution for problems. Using them for the optimization problems has shown that these algorithms often find the closest solution to the optimum and in some cases; they obtain the most optimum solution among the existing solutions in the search space. The genetic algorithm uses a set of population called chromosomes for optimization. These chromosomes are in fact the solutions of the problem. In a search process, the best of them are selected from the solution set available in the search space. Each of these chromosomes is made up of several genes, and these genes represent the parameters that should be optimized. These chromosomes are encoded by numbers. The manner of encoding these genes and chromosomes depends on the type of problem that needs to be solved. Usually, a string of zeros and ones is used for encoding the chromosomes [2].

V) B-SPLINE METHOD

A snake is a curve that evolves from an initial position towards the boundary of an object, minimizing some energy functional [1]. Such functional consists of two terms: the internal energy and the external energy. The first term affects the smoothness of the curve, while the second attracts the snake towards image features. Splines can be effectively integrated in the snake model, as they can characterize a continuous parametric curve by evictor of control points.

The benefit of using splines comes from the implicit properties of the model, including the local support and the control of the continuity of the curve.
Esnake = Eintern(s(u)) + Eextern(s(u))

VI) ACTIVE CONTOUR METHOD

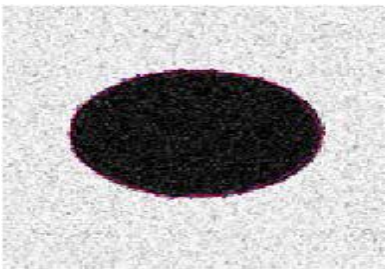
The idea of using an active contour was first brought up by Kass in 1988, which became known as the snake model [2]. Active contour is a two-dimensional curve in the image space whose deformation is based on energy minimization. In this method, first, a primary contour is defined close to the edge of the object in mind and then, in order to detect the edge, an energy function is specified for contour through various arithmetic techniques, the edge detection and segmentation process is completed.

The active contour is one of the methods used extensively in recent decades for segmentation of medical ultrasound images [2] proposed the idea of using active contour for the first time. This method is based on balancing the internal and external forces and minimizing energy.

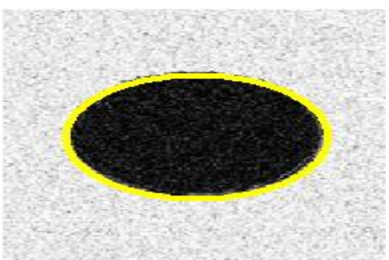
The defined energy function for the contour consists of two components which respectively are Internal energy & External energy. The former is used to control the rate of stretch and to prevent discontinuity in the contour the latter is generated by using the image characteristic features or the limitations imposed on the contour by the user, and it is used for contour displacement.

In order to control the contour deformation and displacement, these energy components are converted into two internal and external forces. During the process of contour deformation, the force resulting from internal energy, keeps the contour smooth and prevents breaking and discontinuity of the contour which are caused mainly by the presence of irregularities and noise in the image. Also, the external force has the task of displacing the contour from its initial position and guiding it towards the subject’s edge.

This image consists of two sections of background and tissue, with some added speckle noise.



(a)



(b)

Fig.1 [2] (a) Original image (b) Segmented image by means of active contour method

The implementation of active contour algorithm on the images is time consuming, so this algorithm cannot be used for real-time image processing and this can be considered as a major disadvantage for this algorithm [2].

VII) FAST-MARCHING METHOD

The fast-marching method was derived from the level-set model introduced by Osher and Sethian to follow an interface (or front, or contour) propagating under a speed function [5]. These methods can be applied to image segmentation by interpreting an image boundary as the propagating interface final position. To achieve this, the speed function is defined in terms of image or shape features and should become close to zero when the propagating front meets with object borders. The interface stop on image boundaries since the speed value is near zero, which ends the segmentation process. Fast-marching is a particular case of the level-set model. It consists of the evolution of an interface propagating under a unidirectional speed function. In this case, the evolving contour must be inside the region to segment (for a positive speed function or outside for a negative one) because the front does not explore its initial inside region.

VIII) WATERSHED SEGMENTATION

The watershed segmentation is an algorithm that splits an image into areas, based on the topology of the image. The gradient values from the gradient maps are interpreted as elevation information. This segmentation results into sharp 1-pixel wide boundaries [3]. Watershed algorithm can be seen as flooding technique starting from local minima. The pixels are sorted in increasing order of gradient values, which efficiently accelerates the algorithm. Then, progressive flooding of the catchment basins in the gradient image is performed, starting with the lowest catchment basin. Starting from this lowest altitude, the water gradually fills up the first catchment basin. Suppose the flooding reaches a given level h. Every catchment basin whose corresponding minimum is smaller than or equal to h is assigned a unique label. Thus each label corresponds to a unique region. Then we find the catchment basins for level h+1. New catchment regions are given new labels. If two different catchment basins are being merged in level h+1, then 1-pixel wide dam is build to prevent merging of the two regions. Therefore, at each level of the flooding procedure, the labeled catchment basins are extended and new catchment basins are detected. This procedure is repeated until every pixel in the image has been assigned a label. The dams build to prevent merging at each stage are the final boundary of different region.

IX) CONCLUSON & FUTURE SCOPE

Here we discussed about the Ultrasound Images and their advantages in medical field. Because of increasing applications of ultrasound images in the field diagnosis as well as therapeutic purposes we need to enhance the features which we require for further processing. There are different techniques for doing this. One of these is segmentation which is a wide area of image processing. In this paper we have discussed various ultrasound image segmentation techniques. Each technique or method has its own advantages & disadvantages. Ultrasound Image segmentation is a challenging task and there is a need and huge scope for future research to improve the accuracy, precision and speed of segmentation methods.

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