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QUANTITATIVE ANALYSIS OF SEGMENTATION METHODS ON ULTRASOUND KIDNEY IMAGE

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Abstract: Image segmentation is an important processing step in many image, video and computer vision applications. Extensive research has been done in creating many different approaches and algorithms for image segmentation, but it is still difficult to assess whether one algorithm produces more accurate segmentations than another, whether it be for a particular image or set of images, or more generally, for a whole class of images. The most common method for evaluating the effectiveness of a segmentation method is subjective evaluation, in which a human visually compares the image segmentation results for separate segmentation algorithms, which is a tedious process and inherently limits the depth of evaluation to a relatively small number of segmentation comparisons over a predetermined set of images. The purpose of this paper is to describe a framework for evaluating ultrasound kidney image segmentation using various algorithms like Edge detection; Watershed segmentation; Region based segmentation and Clustering Method. We prove here that the K-means clustering gives better result for kidney image segmentation because of less intensity variations in ultrasound kidney image and the results are compared with other segmentation methods.

Keywords: Image Segmentation, Objective evaluation, Edge Detection, Watershed, Region Based, Clustering Method.

I. INTRODUTION

Medical diagnosis seeks information from various sources for proper conclusions on diseases. The sources can be results of clinical tests, patient history, histological reviews, and imaging techniques. Imaging techniques have contributed a lot to the development of medical diagnosis. One such safe and easily available technique is the ultrasound imaging technique. But the methodology has certain disadvantages, as the images are not very clear and needs an expert to intervene and segment the organ from the image. Moreover, the process takes considerable time for the expert to get the image and to identify the particular part he/she wishes to examine. Further, the process also causes discomfort to the patient. Delay in diagnosis and lack of clarity of image are major issues. A great deal of expertise is needed to get to conclusions using this imaging technique.

In Europe, kidney cancer accounts for nearly 3% of all cancer cases [1]. Laparoscopic partial nephrectomy or minimally invasive surgery is the standard treatment for kidney surgeon for small tumors (4cm or less). A successful partial nephrectomy means the tumor is completely remove, but some amount of healthy tissue is left in the organ. In order to do this, identification of the location and shape of the tumor inside the kidney is important. Ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI) are currently utilized by doctor to predetermine the location, size and shape of the tumor before surgeon. Compare to CT and MRI ultrasound has the advantage of short acquisition time, less radiation. But ultrasound images usually contain strong speckle noises and artifacts, which makes it difficult to properly segment the interested objects with correct position and shape. Segmentation remains as a challenge task in pre-operative surgical planning. Several approaches have been proposed to segment ultrasound tumor images for diagnosis of tumors, such for the breast tumor [8]. However, very little has been done in kidney tumor segmentation. In [3] the authors proposed using ultrasound to acquire images of the tumor and the surrounding tissues, then segmenting these US images to present the tumor as a three dimensional (3D) surface. In this paper, different segmentation methods are applied for ultrasound kidney image for the diagnosis of kidney cyst in earlier stage. These measures allow a principle comparison between segmentation results on different images, with differing numbers of regions and which is generated by different algorithms with different parameters.

A. Need for Segmentation

The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. In order to

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extract a particular portion from an image for better diagnosis. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

B. Segmentation for Medical Images

- Locate tumors and other pathologies
- Measure tissue volumes
- Computer-guided surgery
- Diagnosis
- Treatment planning
- Study of anatomical structure.

II. MATERIALS & METHODS

A. Method

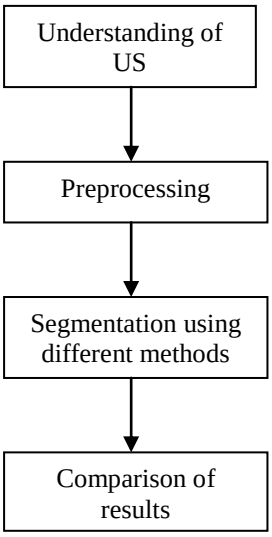

Fig. 1 Process flow

B. Image Acquisition and Preprocessing

Much attention is now being focused on techniques to improve the quality and information content of ultrasonic images of the body. Many of these techniques employ digital pre-processing of coherent echo signals prior to image generation. Examples of these procedures include: resolution enhancement; contrast enhancement (using frequency-domain techniques) to suppress speckle; and imaging of spectral parameters (which sense the sizes and concentrations of sub-resolution tissue constituents). Combinations of spectral parameters and ancillary clinical data (e.g., PSA blood levels) are also being used with statistical classifiers (e.g., discriminates analysis neural network) to generate color-coded, images that indicate tissue type (e.g., cancer) or tissue regions responding to therapy. Sets of these images, obtained from serial-plane scans.

C. Image segmentation methods

The algorithms that we used for ultrasound lesions image segmentation can be divided into the following 5 categories:

- Edge or boundary based methods
- Region based methods
- Texture based methods
- Watershed Segmentation
- Model Based Segmentation
- Clustering Method

1) Edge or boundary based methods

Edge or boundary based methods attempt to solve the image segmentation by detecting the edge between different regions. The edge method has the advantage that it analysis the images by drastically reducing the amount of data to be processed, while at the same time preserving useful structural information about object boundaries [9]. For ultrasound images which have inherent speckle noise and texture characteristics, edge detector only algorithms cannot achieve high quality result. Therefore, traditional edge detection method rarely used alone [13]. In [14], it introduced a combination of canny edge detector with gradient vector flow algorithm. By coupling the smoothness of the edge map to the initial size of the snake, enhancing the tumor boundaries, better tumor boundary have obtained. Different from [14], we use canny edge operator with level set function.

2) Region based methods

Region based techniques is frequently used in ultrasound image segmentation. Region based method use a set criteria, like image intensity, texture, histograms, and gradient to distinguish and connect neighborhood pixels, then assign pixels to object [17-21]. Region growing as one of the most common region based algorithm, starts from seed and seed area, continues merging the neighbor pixels until the completion of all pixels of the connection. We combine region growing and other algorithms for kidney tumor segmentation. Firstly, Otu method [11] is used to assign image pixels into different class. Morphology operation, such as erosion and dilation [10] is applied later to smooth the sharp edge. After that region growing is used to obtain the interesting tumor area.

3) Texture based methods

Each texture can be thought as containing a narrow range of frequency and orientation components. Thus textures can be used to perform tasks such as the segment the ultrasound image into distinct objects and then analysis surface geometries. By using texture filter like multiple band-pass filters filter, the image tuned to the frequency dominant and orientation component, it is possible to localize similarities in texture image. The output of the filters can be used to determine the regions occupied by

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the textures. Gabor filter is used here as our test algorithm. The Gabor filters [16], are band-pass filters with tunable center frequency, orientation and bandwidth. The filter outputs reflect the spatial and orientation composition of a texture.

4) *Watershed Segmentation*
Watershed segmentation is a way of automatically separating or cutting apart particles that touch. It starts with a mask or binary image, where the particles are (say) black. It calculates a distance map to find the fattest parts of the object (the peaks or local maxima of the distance map). Starting with the peaks as maximal erosion points (MEP's), it dilates them as far as possible - either until the edge of the object is reached, or the edge of the region of another (growing) MEP.

4) Model based methods
Markov random field (MRF) model has been used for US image segmentation [22], [25]. The algorithm alternatively approximates the maximization of the posterior estimation of the class labels, and estimates the class parameters. Image segmentation using MRF model include: definition of neighborhood system; the choice of energy function and parameter estimation; minimization of energy function in order to obtain maximum a posteriori probability of the strategy. Here, we use k-means algorithm to get initial label image estimation for MRF. K-means algorithm is a clustering algorithm. It iteratively assigns pixels to the closest cluster using a distance function, such as the Euclidean distance measure. After obtain label image, MRF is applied to segment the tumor from image.
5) Clustering methods
Clustering is an unsupervised learning task, where one needs to identify a finite set of categories known as clusters to classify pixels. Clustering use no training stages rather train themselves using available data. Clustering is mainly used when classes are known in advance. A similarity criteria is defined between pixels, and then similar pixels are grouped together to form clusters. The grouping of pixels into clusters is based on the principle of maximizing the intra class similarity and maximizing the inter class similarity. The quality of a clustering result depends on both the similarity measure used by the method and its implementation. Clustering algorithms are classified as hard clustering, k- means clustering, fuzzy clustering, etc.

III. RESULTS & DISCUSSION

There are two significant categories of kidney cysts: simple cyst and complex cyst. The simple kidney cyst is very common and has no risk of becoming a kidney cancer. The complex cyst refers to a spectrum of cysts that have different characteristics which may make them suspicious for kidney cancer [23]. In Figure 2, a) is ground truth defined by radiologist; b) to f) are the segmentation results from 5 algorithms. We tested the algorithm on a kidney cyst ultrasound image.

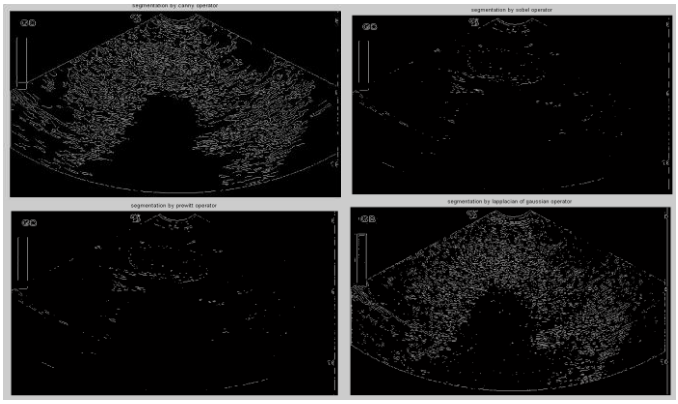

Fig.2 Edge detection output

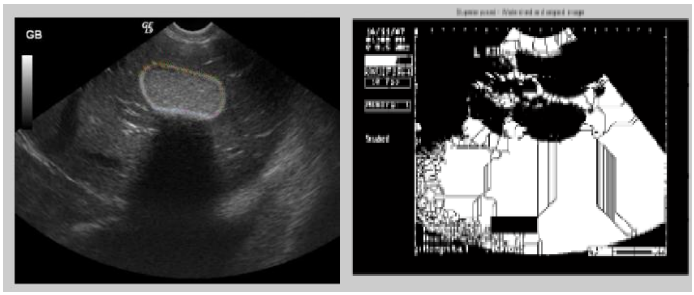

Fig. 3 Region based Segmentation output

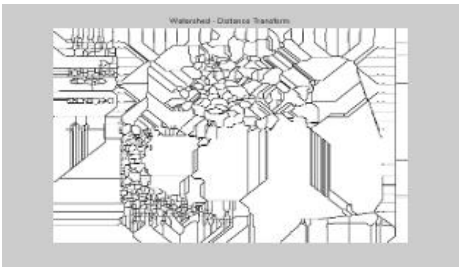

Fig. 4 Watershed Segmentation output

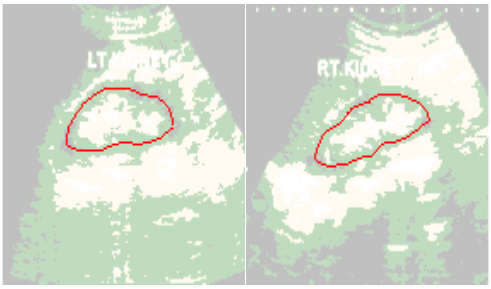

Fig. 5 k-means clustering displaying the Segmented Kidney

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A. Disadvantages of Edge detection, watershed, and region based segmentation:

1. ***Over segmentation:*** When the watershed transform infers catchment basins from the gradient of the image, the result of the watershed transform contains a myriad of small regions, which makes this result hardly useful. The use of a marker image to reduce the number of minima of the image and, thus, the number of regions, is the most commonly used solution. Also interesting is the utilization of a scale space approach to select the interesting regions, using different filters.

2. ***Sensitivity to noise:*** Local variations of the image can change dramatically the results. This effect is worsened by the use of high pass filters to estimate the gradient, which amplify the noise. Anisotropic filters have been used to minimize this problem.

3. ***Poor detection of significant areas with low contrast boundaries:*** If the signal to noise ratio is not high enough at the contour of interest, the Region based will be unable to detect it accurately. Furthermore, the watershed transform naturally detects the contours with higher value between markers, which are not always the contours of interest.

TABLE 1
A. Comparison of Different Segmentation Methods

Sl.No	Segmentation methods	Results obtained
1)	Edge detection method	(1) Does not work well with images in which the edges are ill-defined or there are too many edges (2) It is not a trivial job to produce a closed curve or boundary (3) Less immune to noise than other techniques, e.g., Thresholding and clustering
2)	Watershed segmentation method	(1)The major disadvantage of this method is over segmentation will occur, it is sensitive to noise so the noise present in the image cannot be removed (2) poor detection (3) Does not work well for an image without any obvious peaks or with broad and flat valleys
3)	Region based segmentation method	(1) While using seed selection method, after selecting the seed instead of the diseased part the intensity of that part alone separated. (2) Region growing has inherent dependence on the selection of seed region and the order in which pixels and regions are examined
4)	Clustering method	In intensity based clustering methods especially K-means clustering method gives the best segmentation, because the intensity variations in the ultrasound kidney image will be less, so the clustering process will become very easy ad it is straightforward for classification and easy for implementation

4. ***Poor detection of thin structures:*** When the edge detection is applied on the gradient image, the smoothing associated with gradient estimation, together with usual approach of storing gradient values only at the image pixel positions rather than with sub-pixel accuracy, makes it difficult to detect thin catchment basin areas. Often this is critical for successful segmentation of medical images. Latterly, much interest has been raised in the medical imaging community about segmentation algorithms that use active contours or surfaces.

IV. CONCLUSION

The overview of various segmentation methodologies applied for digital image processing is explained briefly. The study also reviews the research on various research methodologies applied for image segmentation and various research issues in this field of study. This study aims to provide a simple guide to the researcher for those carried out their research study in the image segmentation. Image segmentation has a promising future as the universal segmentation algorithm and has become the focus of contemporary research. In spite of several decades of research up to now to the knowledge of authors, there is no universally accepted method for image segmentation, as the result of image segmentation is affected by lots of factors, such as: homogeneity of images, spatial characteristics of the image continuity, texture, image content. Thus there is no single method which can be considered good for neither all type of images nor all methods equally good for a particular type of image. Due to all above factors, image segmentation remains a challenging problem in image processing and computer vision and is still a pending problem in the world.

This paper shows that hypothesis testing for segmentation is an effective direction to Segment an ultrasound Kidney Image. Intensity variations in the ultrasound kidney image will be less, so the k-means clustering process is highly efficient in ultrasound kidney image segmentation, to compare the features of abnormal and normal medical images and evaluating the significance of the results.

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BIOGRAPHY

Vijay Jeyakumar was born on April 6th 1984, Madurai. He obtained his bachelor of Engineering in Electronics and Communication Engineering from Anna University, Chennai in 2005 and obtained his M.E in Medical Electronics from College of Engineering, Guindy Campus, Chennai, in 2008.Currently he is working as Assistant professor in the department of Biomedical Engineering, P.S.N.A College of Engineering and Technology, Dindigul. He has more than five years of experience in the field of teaching. He has organized and attended many workshops and seminars in the field of Medical Electronics. He has published papers in National and International Conferences. Recently he has filed one patent. His areas of interests are Medical informatics and Image Processing. He is an active member of IAMI and IE (India).

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