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Automatic seed point selection in ultrasound echography images of breast using texture features



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ABSTRACT

Automatic segmentation of breast lesions in 2D ultrasound B-scan images via active contours, require a seed point to be selected inside the breast lesion. The grey levels on an ultrasound image of the breast show intensity information. The fat tissue is hypo echoic relative to the surrounding glandular tissue. The glandular parenchyma tissue usually appears homogeneously echogenic as compared with fat lobules. Simple cysts are anechoic. Malignant solid masses are usually heterogeneous, hypo echoic and tend to look intensely black compared to surrounding isoechoic fat. Benign solid masses tend to appear on ultrasound with intense and uniform hyper echogenicity. Texture features represent changes in grey level intensities. This paper proposes a method that can automatically identify a seed point based on texture features and allow automatic contour initialization for level set segmentation. This seed point plotted on an US B-scan image is mapped on to its corresponding elastogram pair. The proposed approach is applied to 199 ultrasound B-scan images of which 52 are benign solid masses, 84 malignant solid masses and 63 simple and complex cysts. The seed point obtained using this approach is mapped to its corresponding elastogram pair in 62 US B-scan and US elastography image pairs. Quantitative experiment results show that our proposed approach can successfully find proper seed points based on texture values, in ultrasound B-scan images and therefore in elastography images, with an overall accuracy of 86.93%. This approach is effective and makes segmentation of breast lesions computationally easier, more accurate and fast.

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1. Introduction

Ultrasound imaging is one of the most commonly used approaches for early detection of breast cancer. For proper accuracy of computer-aided diagnosis of breast lesions segmentation plays a vital role [1]. There are many texture

features that have been used in the literature (statistical, structural, model based, transform based/spectral). Common statistical approaches include the grey level co-occurrence matrix (Haralick et al., 1973) and the grey level run length matrix (Galloway, 1975). Texture features derived from Haralick's co-occurrence matrices, although computationally intense, has performed well in a number of applications [2].

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Segmentation of breast masses in ultrasound echography images is one of the key points in computer aided diagnosis of breast masses. The two main approaches of image segmentation through active contours are edge based and region based. The edge based method of image segmentation is based on threshold or local filtering. Gradient method of edge detection detects edges by looking for maximum and minimum in the first derivative of an image. Laplacian method of edge detection searches for zero crossings in the second derivative of the image to find for edges. Region based active contour method looks for uniformity of intensity, texture or color within a sub region. It uses statistical information of image intensity within each subset instead of searching geometrical boundaries. Level set method of active contour was proposed by Osher and Sethian. This level set method drives an initial curve based on gradient or region information to the image boundaries. The geometric active contour method evolves a higher dimensional function whose zero-level set corresponds to the position of the propagating contour. This can handle merging and splitting of the evolving contour. However level set method has two limitations. First, this method is by solving PDE and is computationally intense. Second, selection of a seed point inside the lesion area and placement of an initial contour around the seed point occupies much of the computational task. A good initialization avoids local solutions and also reduces the iterative times the curve evolution takes [3].

A few methods have been reported in the literature for automatic seed point selection in ultrasound echography images: A seed point score formula is used to evaluate a set of randomly selected points. The point with the highest score is considered as the seed point [12]. In yet another method [13], after preprocessing and morphological operations, a binary image is obtained and the sum of the pixels on each row and column are computed. Indices of the seed point are found as the row and column number with the max sums, respectively. In yet another method of automatic seed point selection, both texture features and spatial characteristics of lesions are considered [14].

The outline of the paper is as follows. Section 2 presents the appearance of various breast tissues and abnormal breast masses in ultrasound echography images and calculation of texture features. The workflow of a novel approach of automatic seed point selection in breast echography images and initialization of contour followed by segmentation using region based level set approach and cost function of level set segmentation in echography images are also presented in Section 2. The results of texture feature calculation, seed point selection, segmentation in breast US B-scan images are presented in Section 3. Finally performance of the proposed seed point selection and accuracy of level set segmentation is analyzed.

2. Methodology

2.1. Image acquisition

In this work, a total of 199 ultrasound B-scan images are used of which 84 are images of malignant mass, 52 are images of

solid benign lesion and 63 are images of simple and complex cysts. Apart from this, 62 elastography images are also tested with this approach for the purpose of validation. This study is a retrospective analysis of stored images and has no impact on the clinical management of patients. The stored images used for the study are anonymous. The ultrasound B-scan and elastography images are taken from the database. The images were obtained on a Siemens ACUSON Antares scanner with a high-frequency linear VF 7-3 MHz transducer.

2.2. Segmentation of lesion

The following steps are involved in the segmentation of abnormal masses in US B-scan images of breast

- (1) Preprocessing of ultrasound images by SRAD filter [4] to reduce noise and speckle
- (2) Automatic seed point selection in US B-scan images using the proposed algorithm
- (3) Gray-value thresholding [5] of the preprocessed image to obtain a binary image
- (4) Detect position of seed point inside lesion and to trace an initial contour around the seed point automatically
- (5) Apply level set method of contour evolution to segment the area of lesion in breast ultrasound images.

Due to noise and speckle in ultrasound B-scan images, noise filtering and edge-enhancement are required. The image quality is significantly improved by SRAD filter [4] while preserving the important boundary information and hence, in the present study, speckle reducing anisotropic diffusion filtering of real ultrasound B-scan images and elastography images is done to reduce noise and speckle.

Active contour is a robust method for US image segmentation. The level set method drives an initial curve based on gradient or region information to the image boundaries. The geometric active contour method evolves a higher dimensional function whose zero-level set corresponds to the position of the propagating contour. This can handle merging and splitting of the evolving contour. In the present study 'level set active contour method' [10] based on the second criteria is used for segmentation. It is more robust than the method originally proposed by Osher and Sethian [6].

Region based level set active contour does not use gradient information. But the image is separated into regions based on intensities. An image I defined on Ω is assumed to be composed of two regions with homogeneous intensities with values around C_0 and C_1 . For a curve C that defines the boundary of a region inside the image I , a homogeneity based functional is introduced.

$$E(C) = \int_{\text{inside } C} |I - C_0|^2 d\Omega + \int_{\text{outside } C} |I - C_1|^2 d\Omega \quad (1)$$

C_0 and C_1 are the average intensity values of I inside and outside the curve C . $E(C)$ is the energy or force from image information. The segmentation of image plane Ω is computed by locally minimizing the energy functional $E(C)$ [15]. The key idea is to evolve the boundary C from some initialization in direction of the negative energy gradient, which is done by implementing the gradient descent equation and the

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