Development of Breast Ultrasound CAD System for Screening

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Abstract. Mass screening of breast cancer utilizing mammography (MMG) has been widely carried out. However, MMG might not be able to depict small impalpable masses in dense breast tissue clearly. We have developed a computer-aided detection (CAD) scheme in whole breast ultrasound (US) system for mass screening which has been developed by ALOKA CO., LTD., Japan. Our CAD scheme and image processing techniques have the following three benefits.

1. Indication of mass candidates by our CAD scheme.
2. Visualization of breast US images in two views of B-planes (CC View and ML View) and C-plane.
3. Comparison of left and right breast images as in MMG.

The performance of the CAD scheme in detecting malignant masses on an initial study has a true positive fraction of 0.91 (10/11) at a 0.69 (633/924) false positive per image. Although mass screening utilizing US was not appropriate because images acquired by conventional hand probe were poor in reproduction, the problem could be solved in our system.

1 Introduction

Among Japanese women, breast cancer has the highest incident rate of all cancers. In Japan, breast cancer screening using mammography has been establised for women over 40 years of age with the recommendation of the government. When interpreting mammograms, small impalpable masses might be overlooked when dense breast tissue obscures these small masses, and younger Japanese women tend to have dense breast tissue. Ultrasonography can depict these masses even if they have dense breasts. Hence, breast mass screening by ultrasonography has started in some regions in Japan. However, it is difficult for inexperienced radiologists to interpret ultrasound (US) images because the quality of US images

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is poorer than that of mammograms. In addition, the large volume of screening US images can be a burden to radiologists. Computer-aided detection (CAD) systems on US images can reduce oversights of masses and provide valuable second opinions to radiologists.

Many CAD schemes for detection and classification breast masses have been reported. Giger et al. have reported an automatic lesion detection technique using a radial gradient index filtering[KD1, MK1]. They have also investigated breast mass classification using a Bayesian neural network and computer-extracted lesion features[KD1, KD2]. Chang et al. have proposed a method that finds suspicious frames among whole breast US images using watershed segmentation[RC1]. We have developed a CAD scheme based on active contour and balloon models in 2-D and 3-D spaces[DF1, TH1]. However, these automated mass detection methods require substantial computation time in analysing. In addition, some systems also need a radiologist to indicate the mass position on a US image manually. Extracting a mass region from segmented regions is difficult, because US images are noisy when compared with mammograms. Boundaries between two regions are obscure due to speckle noise. Moreover, in a mass with a disappearance posterior echo, it is very difficult to determine the extension of a region accurately.

In this study, we investigated CAD system for the detecting masses based on the orientation of edges.

2 Materials

The ultrasound images were acquired by a whole breast mechanical scanner ASU-1004 (ALOKA Co.). This system has 6cm linear transducer with a frequency of 6-10 MHz. The scanner can scan 16 x 16cm of the breast area automatically by three separate path scans. These path data overlaps 1cm width as shown in Fig. 1 and it has B-plane images with 0.125-2mm intervals.

In this study, a whole breast image usually consist of 84 slices (image size:694 x 400 pixels, 256 graylevels, slice interval:2mm) . Our database is consist of 11 whole breast files(924 slices) diagnosed by experienced radiologists. The distribution of database is 11 malignant masses (65 slices), 3 fibroadenomas (8 slices) and 8 cysts (53 slices).

3 Methods

3.1 Image Integration

Whole breast images are prepared by integrating with three path images. The composite image $f_i(x, y)$ is calculated as

$$f_i(x,y)=\begin{cases} g_i(x,y+\Delta y_i) & ((x,y)\in g_i,(x,y)\notin g_{i-1}) \\ g_{i-1}(x,y) & ((x,y)\in g_{i-1},(x,y)\notin g_i)\ (i=2,3) \\ \alpha g_i(x,y+\Delta y_i)+(1-\alpha)g_{i-1}(x,y) & ((x,y)\in otherwise) \end{cases} \tag{1}$$