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● *Original Contribution*

CLINICAL EVALUATION OF A 3-D AUTOMATIC ANNOTATION METHOD FOR BREAST ULTRASOUND IMAGING

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Abstract—The routine clinical breast ultrasound annotation method is limited by the time it consumes, inconsistency, inaccuracy and incomplete notation. A novel 3-D automatic annotation method for breast ultrasound imaging has been developed that uses a spatial sensor to track and record conventional B-mode scanning so as to provide more objective annotation. The aim of the study described here was to test the feasibility of the automatic annotation method in clinical breast ultrasound scanning. An ultrasound scanning procedure using the new method was established. The new method and the conventional manual annotation method were compared in 46 breast cancer patients (49 ± 12 y). The time used for scanning a patient was recorded and compared for the two methods. Intra-observer and inter-observer experiments were performed, and intra-class correlation coefficients (ICCs) were calculated to analyze system reproducibility. The results revealed that the new annotation method had an average scanning time 36 s (42.9%) less than that of the conventional method. There were high correlations between the results of the two annotation methods ($r = 0.933$, $p < 0.0001$ for distance; $r = 0.995$, $p < 0.0001$ for radial angle). Intra-observer and inter-observer reproducibility was excellent, with all ICCs > 0.92. The results indicated that the 3-D automatic annotation method is reliable for clinical breast ultrasound scanning and can greatly reduce scanning time. Although large-scale clinical studies are still needed, this work verified that the new annotation method has potential to be a valuable tool in breast ultrasound examination. (E-mail: ypzheng@ieee.org) **© 2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Breast ultrasound, Breast imaging, Annotation, 3-D ultrasound, Breast cancer, Clinical study.**

INTRODUCTION

Breast ultrasound is a common diagnostic method for patients with breast cancer in clinics because it is non-invasive, real time and less expensive (Dixon 2008; Huang et al. 2008; Jackson 1990). It has good sensitivity in dense breasts and, thus, is employed as a complementary method to mammography for breast screening (Chen et al. 2004; Svensson 1997). In clinics, breast ultrasound can also be used to differentiate benign from malignant lesions, which can help to reduce the number of biopsies (Cho et al. 2006; Hong et al. 2005).

Figure 1a is a typical ultrasound display during breast examination; it consists of an ultrasound image and the corresponding image annotation. The annotation is used to register the image location with respect to the breast (American College of Radiology [ACR] 2011). Because the follow-up diagnosis, evaluation and treatment are performed on the basis of the stored annotation, it is crucial that the annotations be accurate and complete. The stored annotation is also very important for surgery. For women with large tumors, such as a malignant lesion located across different quadrants, mastectomy is usually recommended (American Cancer Society [ACS] 2014). As illustrated in Figure 1a, there are two parts to the annotation, a graphic pictogram and a textual sequence. In the graphic pictogram, the *circle* represents the breast region. The *irregular part* next to the circle represents the arm, which is used to indicate the laterality (left or right) of the breast. The *arrow* is the probe icon, which represents the probe location. The arrow direction is the probe direction, and the movable arrow can be manipulated by the operator to reflect the current location of the ultrasound image. Most commonly, a trackball on the ultrasound

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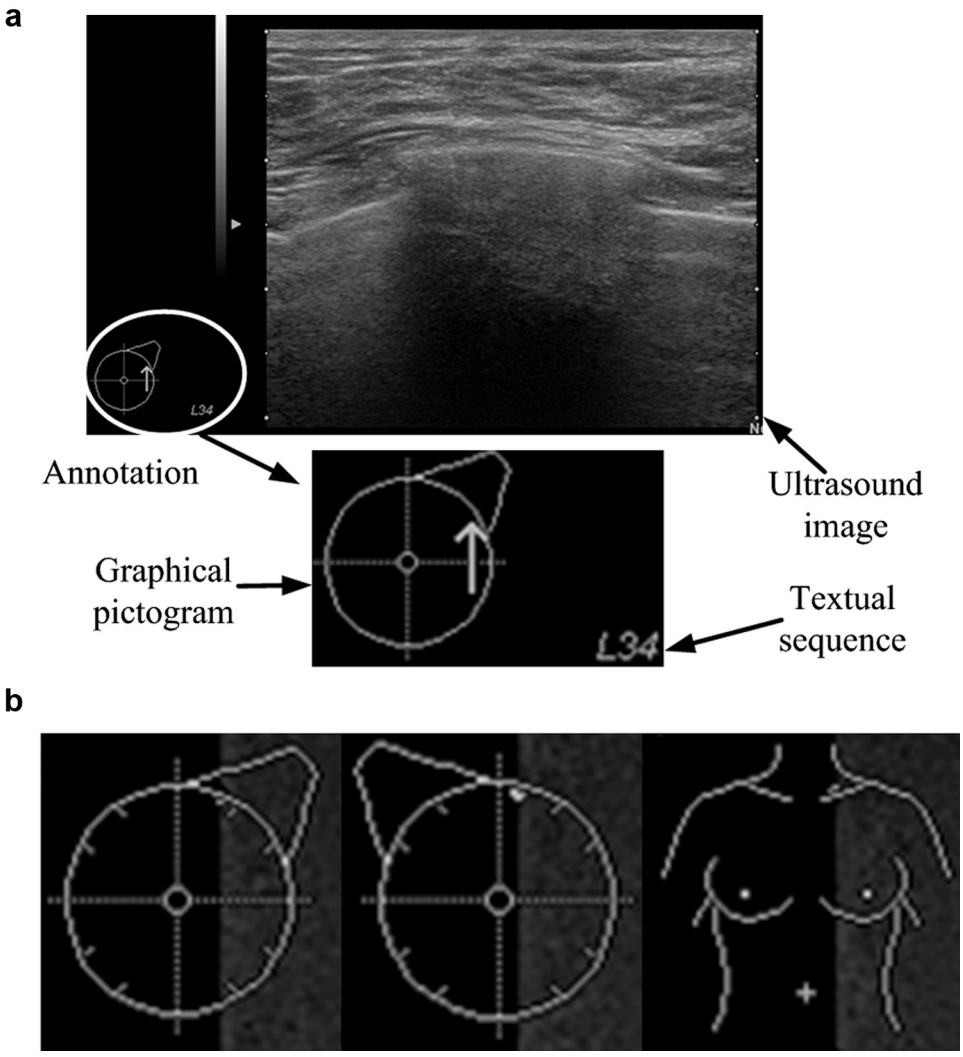

Fig. 1. Typical ultrasound display in breast examination. (a) Typical annotation components including the graphic pictogram and textual sequence. (b) Three common types of graphic pictogram.

machine is employed to manipulate the position of the probe icon relative to the breast marker region. There are three types of breast marker, as illustrated in Figure 1b. The operator can choose a suitable pictogram to annotate the image according to the image location. The spatial information is also indicated in the textual sequence. In Figure 1a, 'L' means it is the left breast, '3' represents the 3 o'clock radial direction and '4' indicates that it is 4 cm to the nipple.

During breast examination, when one image is useful for diagnosis, a series of complex hand motions need to be performed to annotate the image (Jackson and Chenal 2006; Kuzara and Brown 2006). The operator first freezes the ultrasound image using the freeze button on the ultrasound machine and then the changes the probe icon position according to the estimation. Finally, the textual sequence is typed using the keyboard. In the hospital, patient care and productivity are the main concerns. However, this manual annotation method causes a variety of issues.

One issue arises from the complex manual annotation procedure. The aforementioned actions are repeated for every ultrasound image and are time consuming (Entrekin 2010). The annotation takes more time than the breast scanning procedure, especially for new staff with little experience. In China, the clinical practice guideline recommends that there are two operators in each breast ultrasound examination (Chinese Medical Association 2004). One manipulates the ultrasound machine to scan the breast, and the other records the image and annotates it. This method can effectively decrease examination time, but it is obviously a waste of human resources in health care institutions. In addition, the highly repetitive annotation procedure is also fatigue to the operator.