Systematic 3D ultrasound evaluation of breast lesions

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ABSTRACT

Breast cancer is the most common cancer disease among women in most European countries, and the lifetime risk of getting breast cancer has been estimated to 10%. In the diagnosis of breast cancer diseases, breast ultrasound examination is commonly used as a supplement to X-ray mammography. Ultrasound examination is a non ionizing technique free of adverse effects. Unfortunately, ultrasound is also known as a time-consuming examination technique with high operator dependency, and the results from the examination are difficult to discuss, document and reproduce.

The aim of the project is to develop and evaluate a method for systematic three dimensional ultrasound examination and evaluation of breast lesions.

In the first study, an existing water path breast scanner, developed at the Engineering College of Aarhus, is evaluated in a study involving female volunteers. The breast is immersed freely in a water tank, and scanning is performed by automated linear movement of a transducer during image acquisition. The evaluation study shows limitations caused by image artifacts and errors, and poor quality of the 3D reconstruction.

A new method is proposed and prototype scanners for systematic in-vitro and in-vivo scanning are developed. Scanning is performed with the patient lying prone on an examination table with the breast immersed in a water filled cup. A transducer is fixed at the side of the cup, and examination is performed by rotating the cup 360 degrees. This systematic scanning pattern enables spatial compounding of images acquired from opposite sides of the breast. This image combination can minimize acoustic shadow- and enhancement artifacts, and improve the recognition of lesion border characteristics.

The new method is evaluated during three small sub-studies on ultrasound phantoms and resected breast tissue. The method shows promising results in minimization of ultrasound artifacts and in 3D reconstruction.

A clinical patient trial study is performed at the Department of Radiology, Aarhus Sygehus. A total of 26 patients with palpable breast lesions are examined using the method. The prototype scanner performs satisfactory, and a full examination of both breasts can be performed in approximately 15 minutes.

The quality of the raw images, the compound image combination and the 3D reconstruction obtained with the method is evaluated. Artifacts caused by patient movement, water path enhancement, refraction, and ultrasound reflections from the water surface result in poor resolution and low quality of the reconstructed images. Furthermore, the ultrasound penetration depth and the contrast resolution are limited. Improvements to the method and the mechanical prototype are necessary to obtain an image quality sufficient for clinical diagnosis and evaluation of lesions.