Ultrasound-guided breast biopsy based on multimodality image fusion and lesion tracking

Anton Nikolaev[1], Gert Weijers[1], Hendrik H.G. Hansen[1], Leon de Jong[1], Eleonora Tagliabue[2], Bogdan Maris[2], Vincent Groenhuis[3], Françoise Siepel[3] and Chris L. de Korte[1]*

[1]Department of radiology and nuclear medicine, Radboud University Medical Center, Nijmegen, The Netherlands, [2]Department of Computer Science, Università degli Studi di Verona, Verona, Italy, [3]University of Twente, Enschede, The Netherlands
**anton.nikolaev@radboudumc.nl*

Introduction

Multimodality image co-registration can facilitate ultrasound(US)-guided biopsy even for the lesions that are occult in US. However, this approach is not yet applicable to breast biopsy due to the high deformability of the tissue. Furthermore, the breast shape is different during MRI (prone position) and 3D ultrasound imaging (supine position), making registration challenging.

The objective of the study is to facilitate US guided biopsy of US occult lesions using multimodality MRI-US image registration and custom developed setup for volumetric breast scanning and biopsy.

Methods

To facilitate US-MRI image registration, the volumetric US acquisition was performed with custom developed setup, where the breast was prone positioned with minimal deformation during scanning. The US transducer is integrated into PLA cone-shaped container that revolves 360^o around the breast. The 3D volume was reconstructed by calculating a regression of pixels within each voxel. The container has an array of sealed holes on the opposite side of the transducer to facilitate biopsy. The quality of obtained US images was assessed quantitatively by scanning a custom developed PVA phantom with 8 (15mm diameter) lesions with different echogenicity.

Accuracy of biopsy was validated using a PVA phantom with 4 lesions of 15mm and four lesions of 7mm diameter stained in black color.

Due to the needle insertion, the breast is deformed and lesion will displace from the registered position. To prevent the biopsy mistargeting, the lesion displacement was tracked real time at 10 fps using cross-correlation based speckle tracking algorithm with 5.6 mm x 4.5 mm template and 112 x 102 mm kernel size. All lesions were biopsied, and the presence of stained material was observed in each sample.

Results

The US data acquisition takes 60 seconds. The 3D volume of 200x200x200mm^3 with a voxel size of 0.5x0.5x0.5mm^3 was reconstructed within 60 seconds (Fig.1A and Fig.1.B). Estimated SNR_L of the reconstructed lesion are presented in Fig.1C.

During the lesion tracking the maximum lesions displacement was 9 mm. Lesion tracking was sufficiently accurate for taking biopsies (mean 0.9mm, STD 0.4mm).

After the biopsy, the presence of stained material was observed in all 8 samples demonstrating a 100% biopsy rate that demonstrates feasibility of the approach.

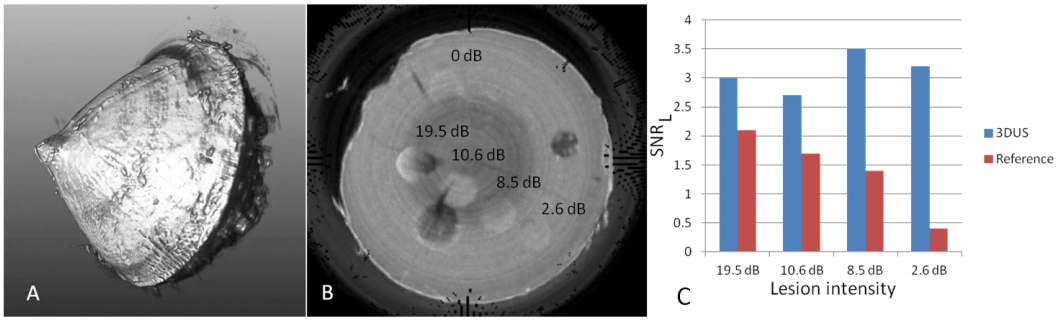

Fig.1. A - rendered 3D breast image; B - breast cross section in coronal direction with lesions of different echogenicity; C - SNR of lesion I reconstructed volume versus reference values.