Automated Breast Ultrasound: MRI and Ultrasound CT Imaging Similarities

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· INTRODUCTION

Breast imaging plays a crucial role in the early diagnosis of breast cancer, the most common cancer in women. Currently, the gold standard for general diagnostics and screening is mammography, whose findings can be complemented with handheld ultrasound and MRI. All of these methods have complementary strengths in terms of diagnosis and screening reliability and efficiency (mammography), high specificity (handheld ultrasound) and sensitivity in dense breast tissue (MRI). However, each method also has inherent disadvantages: use of ionizing radiation (mammography), operator dependency (handheld ultrasound), high costs and high rate of false positive findings (MRI) [1]. Therefore, exploration of new diagnostic techniques continues, trying to combine positive features of the existing ones and avoiding their disadvantages. One example of a new breast diagnostic modality is examined in our study of a prototype automated breast ultrasound computed tomography (USCT) system. Preliminary results of the first 70 patients have helped to build a knowledge pool of characteristic features of pathologic findings in the breast, which in some cases revealed intriguing similarities between USCT and MRI image features.

· METHODS

The pilot study examination protocol includes breast USCT, handheld ultrasound and mammography for every patient. MRI is used when recommended for diagnostic purposes.

USCT imaging was provided by the Warm Bath Ultrasound (WBU) scanner (Techniscan Medical Systems, Salt Lake City, Utah, USA). This automated system acquires a volume image dataset of both transmission and reflection ultrasound of the whole breast [2-4]. The patient lies in a prone position with her breast placed in a water bath. The transmission/receiver array revolves around the breast and one-side transmission and reflection data are acquired, going upwards from the nipple to the chest wall in a 7' interval on average. An inverse scattering algorithm [5] generates 3D maps of both speed of sound and attenuation, along with a 3D reflection map geometrically registered with the previous ones, as shown in Fig. 1. Imaging voxel size is 0.8 mm by 0.8 mm in the coronal view and 1 mm along the anterior-posterior direction, but, due to the presence of noise and due to the convergence tolerance of the nonlinear algorithm, some smearing is expected, leading to an actual spatial resolution of about 1.2 mm by 1.2 mm in plane and 3.3 mm in the third direction.

MRI images were acquired with a 1.5 T Espree MRI scanner (Siemens Medical Solutions, Erlangen, Germany). The protocol follows clinical routine scanning with axial acquisition of 2D TIRM images and a multiphase T1-weighted 3D FLASH sequence (6 time points every 90 s) after application of contrast agent, providing data for subtraction imaging and allowing to calculate region-of-interest uptake curves. Typical spatial resolution is 0.8 mm by 0.8 mm in plane with 6 and 1.5 mm respective slice thickness. Acquisition time is about 15'.

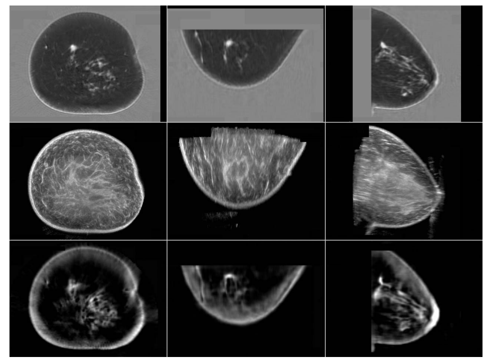

Fig. 1: Ultrasound CT of a 53 year old woman with ductal carcinoma. Left to right and top to bottom: coronal, axial and sagittal breast views of speed of sound, reflection and attenuation imaging, respectively.

· RESULTS

WBU USCT reliably depicts typical breast findings like cysts, fibro-adenomas and carcinomas, whenever the lesion is inside the currently available field of view. Lesion characteristics differ markedly from handheld ultrasound and may present imaging features closer to MRI rather than handheld ultrasound.

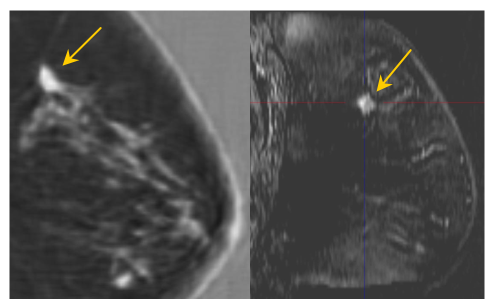

Fig. 2: In fatty breasts the USCT speed of sound imaging (left) directly targets carcinomas (see arrows) as in contrast-enhanced T1-weighted MRI (right).

· DISCUSSION & CONCLUSION

Several common features contribute to the similarities between WBU and MRI imaging. First, the prone, pendent position of the breast allows a good matching of the two imaging techniques, a feature particularly helpful to compare small findings in soft and easily compressible tissue, as is found in the breast. Secondly, the volumetric dataset makes multiplanar reformatting possible, useful for a better characterization of inner structures. As a third point, both spatial resolution and acquisition time are quite similar, which is a crucial issue in clinical routine. Finally, similar imaging contrast features may lead to a prompt diagnosis of breast lesions. One example is presented in Fig. 2 depicting an invasive ductal carcinoma as imaged by contrast-enhanced T1-weighted MRI and WBU speed of sound.

According to preliminary results of our study, the WBU is a promising, original imaging technique for breast diagnostics. A proper merger of reflection and transmission imaging, targeted to further improve lesion characterization without resorting to invasive methods or use of potentially allergy inducing contrast agents or ionizing radiation, has the potential to become a great aid to breast diagnostics and screening. Moreover, being an automated examination, it is endowed with the key features of objectivity and reproducibility.

· REFERENCES

[1] N. Sachin Prasad, D. Houserkova, Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub, **151**(2): 209-218, 2007.

[2] J. Wiskin, D.T. Borup, S. Johnson *et al*., Acoustical Imaging, **28**: 183-193, 2007.

[3] M.P. André, C. Barker, N. Sekhon *et al*., Acoustical Imaging, **29**: 73-80, 2008.

[4] J. Wiskin, D.T. Borup, S. Johnson *et al.*, Acoustical Imaging, **30**, 2010, in press.

[5] J. Wiskin, D.T. Borup, K. Callahan *et al*., SPIE Medical Imaging Conference, **7629:** 76290K-76290K-12, 2010.