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Improved Ultrasound Imaging with X-ray Computed Tomography-based Acoustic Sound Speed Correction

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Abstract— **Ultrasound beamforming relies on a constant sound speed to reconstruct images. However, the sound speed varies in heterogeneous tissues, resulting in beamforming errors and thus image quality degradation. Therefore, this study investigates estimation of sound speed from computed tomography (CT) scan to improve the beamforming accuracy. We have demonstrated that our approach can be successfully applied to ultrasound/CT fusion imaging with improved ultrasound image quality.**

I. INTRODUCTION

Ultrasound is a preferred medical imaging modality, because of its potability, low cost, and safety. Ultrasound is also useful in characterizing soft tissue but has a limitation on imaging of hard tissue. Hence, ultrasound is often combined with different imaging modalities, including x-ray computed tomography (CT), for synergistic benefits. On the other hand, ultrasound image quality can be degraded because of sound speed variation in tissue. In this study, we hypothesize that sound speed can be estimated from CT scans, which can improve ultrasound image quality, and thus, ultrasound/CT fusion imaging as well. Our hypothesis is demonstrated through ultrasound and CT scans acquired from the imaging setup with different sound speeds.

II. METHODS

Figure 1 shows our CT-based sound speed estimation and correction procedures. From the CT scan represented with a Hounsfield unit (HU), tissue density ρ can be first estimated [1]. Acoustic sound speed of tissue c can then be obtained from the estimated density information [2]. After creating an optimal mean sound speed map (OMSSM) with probe geometric information, each image point is then dynamically focused to form ultrasound images.

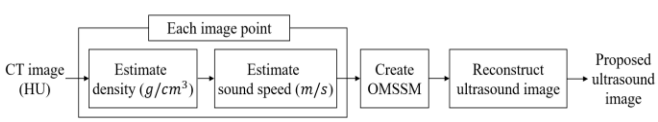

Figure 1. Flow chart of CT-based ultrasound beamforming method.

For experimental demonstration, an ultrasound system (Vantage 128, Verasonics) with a convex probe (C5-2v, Ultrasonics) was utilized. A phantom (040 GSE, CIRS) with a 5-cm water layer on top was imaged with both ultrasound and CT (SOMATOM, Siemens Healthineers) systems.

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III. RESULTS

Ultrasound images reconstructed with a constant sound speed (1,540 m/s) and with CT-based spatially-varying sound speeds are presented in Fig. 1a and Fig. 1b, respectively. It can be clearly observed that lateral resolution and contrast from the point targets and cystic mass are improved. As the sound speed was estimated from the CT scan (Fig. 1c), we formed the fused image of ultrasound and CT using the improved ultrasound image, as shown in Fig. 1d.

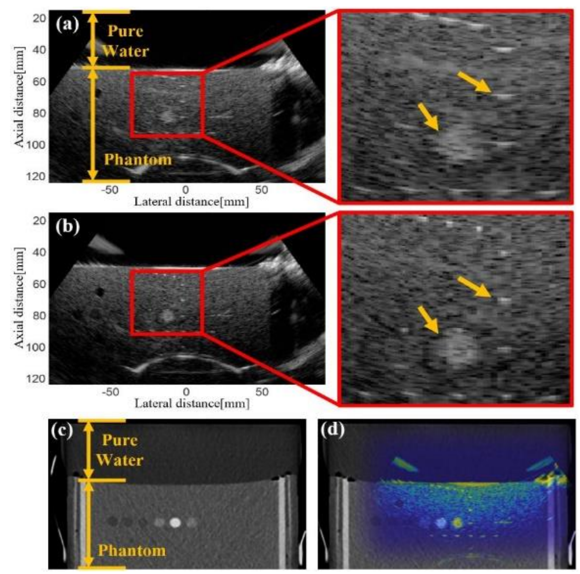

Figure 2. Ultrasound images reconstructed with (a) a constant sound speed (1,540m/s) and (b) CT-based spatially-varying sound speed. (c) Reference image of CT stand alone and (d) ultrasound/CT fusion image.

IV. DISCUSSION & CONCLUSION

We have demonstrated that CT-based sound speed correction can improve ultrasound image quality, which can be used for enhanced ultrasound/CT fusion imaging.

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