Eigen-decomposition based adaptive coherent compounding technique for the volumetric ultrasound imaging with the improved signal-to-noise ratio

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Background, Motivation and Objective

Volumetric ultrasound (US) imaging using matrix array has a strong potential as a promising biomedical diagnostic tool with a capability of multi-planar imaging. The coherent compounding of multiple tilted plane waves that can preserve the volumetric imaging speed suffers from the low signal-to-noise ratio (SNR) due to the electrical impedance mismatch and relatively small element size of the matrix array transducers compared with the conventional linear array. Therefore, an effective noise suppression method has been highly sought after. Here, we introduce the adaptive compounding method using the singular value decomposition (SVD) to enhance SNR in volumetric imaging.

Statement of Contribution/Methods

To evaluate the performance of the proposed algorithm, the imaging was performed using a porcine eyeball embedded in a stiff (7% weight/volume) gelatin. The 1024-element matrix array was connected to the fully programmable US scanner (Vantage 256). Diverging waves (0.2 ms pulse at 5 MHz) from 25 virtual sources were sequentially emitted to the tissue and the volume data was acquired. For the conventional compounding, the quadrature baseband data at each angle was summed. For the SVD-based compounding, SVD was applied to each spatio-angular sub-volume set and the largest eigen-value was chosen to extract only coherent component to place at the centroid of each volume. The logarithmic compression was applied to all envelope data of compounded data with a dynamic range of 30 dB.

Results/Discussion

Ultrasound images reconstructed using conventional and SVD-based approaches are shown in Fig. 1A and Fig. 1B, respectively. The selected axial profile (Fig. 1C) shows that the SVD-compounding results in 3.5-7.0 dB noise suppression. Our results suggest that the proposed method successfully decomposed the noise and coherent signal components resulting in measurable improvement of volumetric image quality.

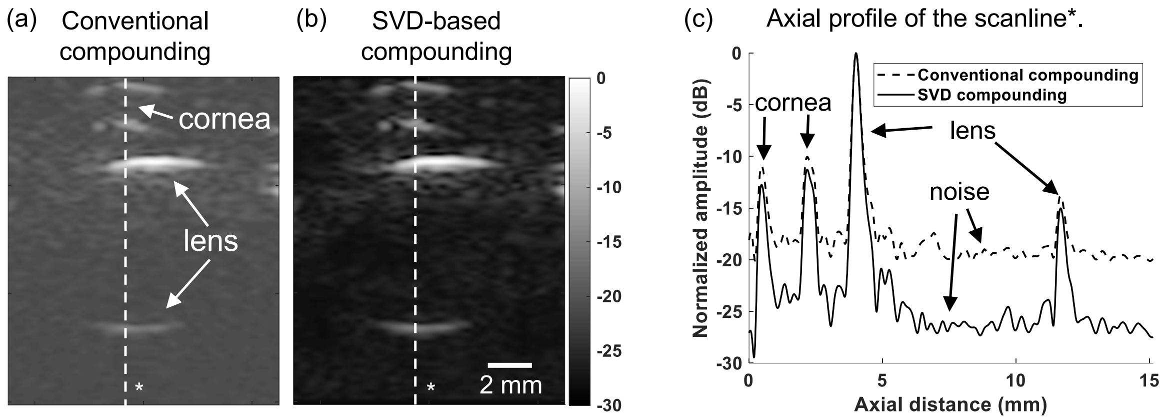

Figure 1. 2-D images of the volume data reconstructed by (a) conventional coherent compounding method, and (b) singular value decomposition (SVD)-based coherent compounding method. (c) The axial profile along the line denoted by asterisk in the panels (a) and (b) indicated that the noise is significantly (3.5 dB to 7.0 dB) suppressed using SVD-based coherent compounding method.