Effect of cross spectral accumulation (CSα) on signal-noise separation method of eigenspace-minimum-variance beamformers

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Background, Motivation and Objective

This report addresses the signal/noise separation metrics to further improve the image quality of ultrasound B-mode images by using the eigenspace-minimum-variance (ESMV) beamformers. Previously, main component (MC) and cross spectral (CS) based signal/noise separation methods for ESMV beamformers have been reported. However, our preliminary results suggest that by using real data taken by a medical ultrasound imager, the both MC- and CS-based separation methods cause "zebra-stripe artifacts" to appear in the B-mode image. Also, a definite separation boundary between the signal/noise subspaces cannot be defined in MC and CS arrangements.

Statement of Contribution/Methods

In this paper, we combine the threshold idea introduced in the MC/CS methods and propose the cross spectrum accumulation (CSα) method for signal/noise subspace separation. We first observe that saturation appears when CS values in the CS method are summed through sequential accumulation. Then we set the CSα threshold when the sum is at satulation. The CSα method theorizes that eigencomponents in the saturation region can be considered noise since they do not contribute additional energy. Compared with MC/CS methods, the CSα method is expected to create much smoother images because of its robustness to the energy variance among transmission beams.

Results/Discussion

We validate four separation methods (MC, CS, MC/CS switching, and CSα) using digital phantoms and real data. Results demonstrate that both the CS and MC methods produce degraded B-mode images (Fig. (a) – (c)) but produce high-quality B-mode images when applied to digital simulated data. The proposed CSα method solved the "zebra-stripe" problem and produced B-mode images much similar to those of the DAS and MVDR beamformers (Fig. (d)). Among different transmission firing beams, the variance of beamformed RF-signal amplitude is less than 10 dB for CSα but more than 30 dB for CS, MS, and CS/MS. The results suggest that robustness of signal/noise separation metrics among the transmission firing beams is a significant factor to further improve ESMV beamformes.