Frequency Domain Convolutional Beamforming

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Background, Motivation and Objective

Ultrasound imaging visualizes body structures by using multiple transducer elements to transmit a pulse into the body and receive echoes scattered by the tissues. Signals received by the elements are sampled and digitally beamformed to yield the final B-mode images. The standard beamforming technique is delay and sum (DAS) which is widely used due to its simplicity and low complexity. However, DAS suffers from several major limitations. The sampling rates used to perform high-resolution beamforming are significantly higher than the Nyquist rate of the signal, resulting in considerable amount of data to be stored and processed. Moreover, DAS exhibits poor image resolution and contrast. Enlarging the transducer aperture by increasing the number of elements improves the resolution and contrast but at the expense of an increase in data size. These limitations degrade systems performance and increase cost and power consumption.

Statement of Contribution/Methods

We introduce a technique called Fourier domain sparse convolutional beamforming (Fourier SCOBA) for generating B-mode images. The proposed method combines Fourier domain beamforming and sparse convolutional beamforming algorithm (COBA), allowing a polynomial reduction in the number of elements for the same aperture, along with a 4 to 10-fold reduction in sampling rate at each remaining element. We show that our beamforming leads to an improved beampattern with narrow main lobe and low side lobes. Thus, we obtain a significant data reduction of order of magnitude while providing B-mode images with improved resolution and contrast with respect to DAS. Fourier SCOBA paves the way for high-performance low-cost probes, portable ultrasound systems and wireless operation.

Results, Discussion and Conclusion

We validated the proposed method by applying it on *in vivo* cardiac data, acquired by GE breadboard ultrasonic scanner. The radiated depth was 15.7 cm, the carrier frequency was 3.4 MHz and the sampling frequency was 16 MHz. Below we show the resultant images obtained by (a) DAS (b) Fourier COBA and (c) Fourier SCOBA. Fourier COBA offers an 8-fold reduction in the sampling rate and leads to improved resolution and contrast in comparison with DAS; Fourier SCOBA allows to reduce the number of elements and the sampling rate by factors of 3 and 8 respectively. Thus, Fourier SCOBA leads to a total of 24-fold data size reduction.