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Sparse Arrays for 3D Imaging with Diverging Waves

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Background, Motivation and Objective

Volumetric (3D) ultrasound is an important imaging modality as it allows a noninvasive investigation of inner body structures and blood flow. Real-time 3D imaging enables the visualization of anatomical structures which are intrinsically 3D and thus their complexity cannot be fully captured with 2D techniques. However, 3D imaging requires the use of 2D transducer arrays composed of several thousands of elements, leading to a vast of amount of data that needs to be stored and processed for real time imaging. The latter poses major limitations on 3D imaging, resulting in low frame-rate, poor resolution and contrast that prevent 3D volumetric ultrasound from being a common clinical practice. Therefore, we aim at reducing the acquired data while improving resolution and contrast.

Statement of Contribution/Methods

We introduce a beamforming method for 3D imaging that is based on the design of 2D sparse transducer arrays. It extends the convolution beamforming algorithm (COBA) to 3D imaging with diverging-wave transmission, namely 3D-COBA. The proposed beamformer relies on 2D convolutions of the received signals; we show that with a full array it improves both resolution and contrast in comparison to delay-and-sum (DAS). We then present a sparse 2D array design which exploits the convolution operations to reduce the number of sensors upon reception by a factor of the square root while preserving the beampattern. We evaluate 3D-COBA for diverging-wave acquisitions, and show that it exhibits low complexity while generating high quality 3D images while utilizing the same number of elements comprising a 1D array.

Results, Discussion and Conclusions

To demonstrate the performance of 3D-COBA, we acquired phantom data using 4 *Verasonics* Vantage systems transmitting diverging-waves and a 2D 32x32 elements transducer. The radiated depth was 7.5 cm, the carrier frequency was 2.976 MHz and the sampling rate was 23.808 MHz. Below are the resultant images obtained by (left) DAS, (middle) 3D-COBA (right) 3D-COBA using a sparse array of 196 elements. As can be seen, 3D-COBA exhibits improved contrast and resolution, outperforming DAS using only 196 elements out of 1024 ($\sim 19\%$). This shows that we can perform 3D imaging of high quality using the resources currently required for standard 2D imaging.