Performance Comparison of Synthetic Aperture Focusing and Coherence Factor Weighting for Non-focused and Focused Intravascular Ultrasound Transducers

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Background, Motivation and Objective

Many efforts have been made to improve the spatial resolution of intravascular ultrasound (IVUS) imaging. One of them is the application of synthetic aperture focusing (SAF) and SAF with coherent factor (SACF) at the cost of complicated signal processing. Another is the development of focused IVUS transducers. In SAF, lateral resolution is mainly determined by how many adjacent scanlines can be used for coherent summation to reconstruct a target scanline. The scanline is selected for coherent summation when its position is within the -6 dB lateral width of the beam profile related to a target scanline. Since IVUS imaging uses rotational scanning, the number of scanlines for SAF is expected to be small, especially at the far field. The objective of this study is to ascertain the benefits of SAF and SACF over focused IVUS transducers in terms of lateral resolution enhancement.

Statement of Contribution/Methods

Two IVUS transducers with flat and focused apertures were fabricated; the aperture size was 0.5x0.5 mm^2 and the center frequency was 50 MHz. The focal length of the focused transducer was 3 mm. The image data of four 25-μm gold wires located 1 mm apart at a depth of 2-5 mm were acquired using both transducers. For this, 1000 scanlines were acquired turning a rotary stage at a 0.36° increment. SAF and SACF algorithms were used to reconstruct the wire images, and the -6 dB lateral widths of the wire images were measured and compared.

Results/Discussion

For the flat aperture, since only 9 adjacent scanlines could be used for SAF, the effect of SAF on the lateral resolution enhancement was negligible. SACF using 21 scanlines for a target scanline increased the lateral resolution by up to 1.36 times. However, the improved lateral resolution was inferior to that by the focused transducer without SAF or SACF. The lateral resolution achieved by the focused transducer could be further improved up to 1.58 times when SACF with 21 scanlines was employed. Note that the increase in the lateral resolution by SAF was also negligible in the case of the focused transducer because only 7 adjacent scanlines could be used for SAF. The experimental results show the superiority of focused IVUS transducers over flat IVUS transducers in conjunction with SAF and SACF requiring high implementation cost in terms of lateral resolution; there is not much difference in fabrication cost between non- and focused IVUS transducers.