Optimized Plane Wave Imaging for Fast and High-Quality Ultrasound Imaging

This paper presents a method for optimizing parameters affecting the image quality in plane wave imaging. More specifically, the number of emissions and steering angles is optimized to attain the best images with the highest frame rate possible. The method is applied to a specific problem, where image quality for a λ-pitch transducer is compared with a λ/2-pitch transducer. Grating lobe artifacts for λ-pitch transducers degrade the contrast in plane wave images, and the impact on frame rate is studied. Field II simulations of plane wave images are made for all combinations of the parameters, and the optimal setup is selected based on Pareto optimality. The optimal setup for a simulated 4.1-MHz λ-pitch transducer uses 61 emissions and a maximum steering angle of 20° for depths from 0 to 60 mm. The achieved lateral full-width at half-maximum (FWHM) is 1.5λ and the contrast is −29 dB for a scatterer at 9 mm (24λ). Using a λ/2-pitch transducer and only 21 emissions within the same angle range, the image quality is improved in terms of contrast, which is −37 dB. For imaging in regions deeper than 25 mm (66λ), only 21 emissions are optimal for both the transducers, resulting in a −36 dB contrast at 34 mm (90λ). Measurements are performed using the experimental SARUS scanner connected to a λ-pitch and λ/2-pitch transducer. A wire phantom and a tissue mimicking phantom containing anechoic cysts are scanned and show the performance using the optimized sequences for the transducers. FWHM is 1.6λ and contrast is −25 dB for a wire at 9 mm using the λ-pitch transducer. For the λ/2-pitch transducer, contrast is −29 dB. In vivo scans of the carotid artery of a healthy volunteer show improved contrast and present fewer artifacts, when using the λ/2-pitch transducer compared with the λ-pitch. It is demonstrated with a frame rate, which is three times higher for the λ/2-pitch transducer.

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