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Ultrafast adaptive beamformer based on angular coherence of plane wave compounding

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Background, Motivation and Objective

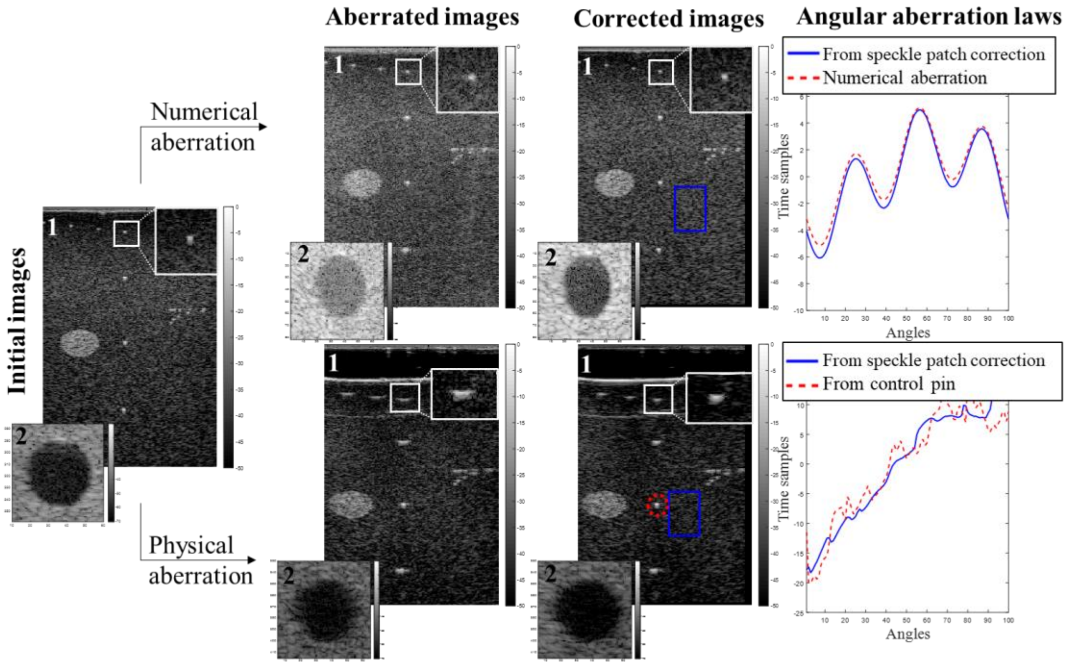
Ultrafast plane wave compounding was introduced to form high quality images at very high frame rates for applications such as Shear Wave Elastography, Ultrafast Doppler, functional neuroimaging or quantitative ultrasound. Though, propagation through complex layers can induce severe aberrations of the acoustic wave front; hindering both image quality and quantitative information assessment.
Several approaches exist to retrieve the phase aberration and tackle this issue: Time-reversal of speckle noise (1), measure of the transmit echo phase (2) or study of backscattered signals coherence (3). According to Van Cittert Zernike theorem, this spatial coherence offers an estimate of the focusing quality and thus, the image quality. In this work, we investigated a new and fast method to exploit and maximize the coherence between steered plane waves, retrieving also the phase aberration profile.

Statement of Contribution/Methods

To ensure a maximal amount of information, 100 plane waves were transmitted on *in vitro* media using a 192-element linear probe (pitch 200 µm, 6.25 MHz central frequency). To confirm our method, both numerical aberration - virtually introduced at emission - and a physical aberrating lens were used. Tests were also conducted in k-Wave and Field II simulations, and on *in vivo* human liver data. In the case of thick aberrating lenses, correction was further improved and performed on isoplanetic patches, giving one phase profile per patch.

Results/Discussion

Comparisons of aberrated and corrected images showed a strong diminution in clutter: contrast on *in vitro* anechoic compartment was improved by 11.7dB for virtual aberration, and 8.5dB for physical aberration. Also, the lateral resolution went respectively from 1.00 to 0.88 mm, and from 2.1 to 1.3 mm after correction. Aberration laws are very consistent (r^2 = 99% and 95%) with expected delays. Those results demonstrate that our method can perform simultaneously efficient correction of the image and aberration phase law extraction. Importantly, its implementation time on a high end PC computer could already be decreased to some tens of milliseconds, which opens the path to real-time adaptive beamforming of ultrafast data.



(1) Montaldo et al. PRL 2011
(2) M.Jaeger et al. PMB 2015
(3) Li et al. JASA 2017