3-D field characterization of unfocused transmissions from a 256-element CMUT spiral array

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Background, Motivation and Objective

3D ultrasound imaging at high volume rates can be obtained through sparsely populated array probes used with unfocused transmissions. Sparse arrays have so far been characterized with focused transmissions, but it has yet to be analyzed how sparse element distribution may impact the ideal plane or diverging waves that are assumed in beamforming. Non-ideal wavefronts would result in aberration artifacts during receive beamforming and in turn reduce image quality. Here, we present the first investigation on the field profiles of unfocused transmissions from a density-tapered 256-element spiral CMUT array. We particularly focused on characterizing the amplitude and phase profiles of emitted fields in view of their high relevance to beamforming.

Statement of Contribution/Methods

The spiral array has 220 µm-wide hexagonal elements distributed over a quasi-circular area of 10 mm diameter [10.1109/ULTSYM.2018.8579867]. The probe was connected to the ULA-OP 256 scanner and driven with 7.5MHz 3-cycle sinusoidal bursts. Acoustic pressure fields were measured at 20, 40, and 60 mm from the array surface using an ONDA HGL-0400 hydrophone and swept over a 20 ×20 mm area (see Fig A) with 0.1 mm steps. Two transmission schemes were considered: 1) plane wave and 2) diverging wave from a virtual point source 20 mm behind the array. Measurements were compared to Field II simulations of the spiral array with 200 µm-wide square elements.

Results/Discussion

For 20 mm scan depth, Fig B shows the peak plane wave amplitude from the spiral probe, while Fig C shows the measured and simulated phase profile of a slice centered on the probe axis. Figs D and E display the same information respectively for diverging waves. Both transmission schemes had non-idealities in their field amplitude map due to the sparsity and density tapering of elements in the spiral configuration. Also, plane waves had a near-flat phase profile only in the center 8 mm (RMS difference: 0.044λ vs. simulation, 0.053λ vs. ideal), whereas diverging waves had a smoother phase profile across the full 20 mm span that fits closely to the ideal curve (RMS difference: 0.180λ vs. simulation, 0.109λ vs. ideal). These results shed light on the need to apply amplitude and phase delay correction factors when performing receive beamforming with a sparse array to improve the resulting image quality.

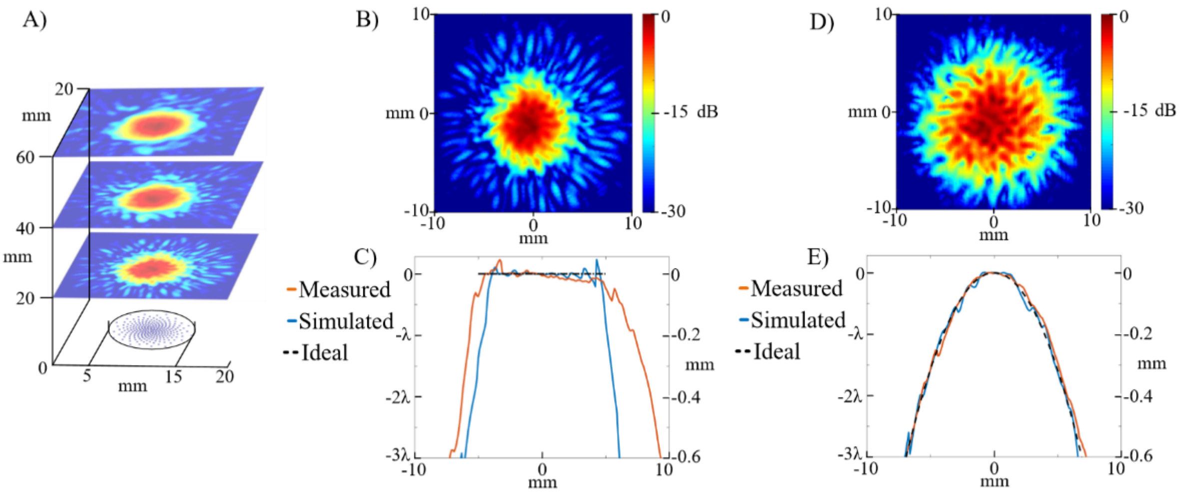

Figure: A) Measurement setup for all depths, B) measured peak amplitude and C) phase profiles for plane wave, and D-E) for diverging wave transmissions all at 7.5MHz and 20 mm depth