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A Low-intensity Ultrasound Delivery System using Acoustic Holograms

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The aim of this work is create curved holographic lenses to adapt large-aperture transducers' focus to deep-brain structures in primates for localized blood-brain barrier opening.

Acoustic holograms were designed using time-reversal methods to adapt the elongated focus of a 100-mm aperture 140-mm focal transducer to the left posterior putamen of a macaque. Focusing performance was evaluated by simulations and validated by experimental ex-vivo measurements in a degassed water tank using a macaca mulata skull. The field near the skull was reconstructed by holographic projections of the experimental far field. A passive cavitation detector was located confocally to monitor microbubble activity.

Good agreement was found between simulated field, direct experimental and holographic projection data. FWHM on the x-axis was of 3, 3.9 and 3.8 mm for simulation, direct measurement, and reconstructed field, respectively, while it was of 2.8, 3.9 and 3.6 in the y-axis. The system was tuned to experimentally generate 0.5 MPa rarefaction pressure at focus, with a total 84% of the focus volume lying in the target region, while cavitation signals were acquired and processed in real.

Acoustic holograms can adapt the elongated focal spot of large-aperture focused transducers to target small deep-brain structures with great versatility. Results show that this technology can provide the typical values for BBB opening in non-human primates, paving the way to apply this low-cost system for localized preclinical drug screening.

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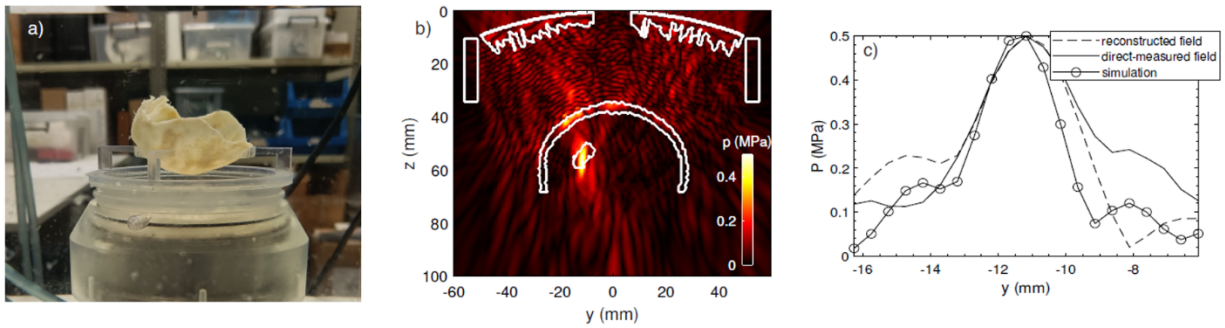


Figure 1. a) Experimental set-up. b) Simulated acoustic field with holographic lens. c) Comparison between simulated and experimental acoustic fields.