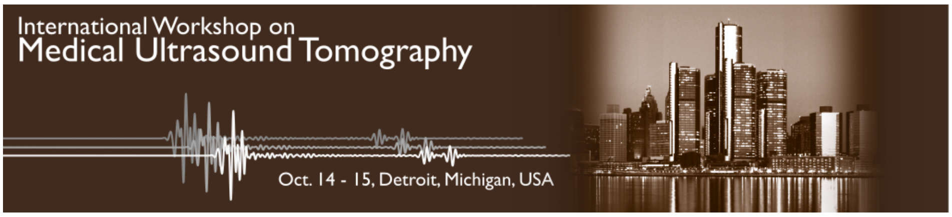

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Ultrasound transducer identification enables high-resolution full-waveform inversion

Background

Full-waveform inversion (FWI), a technique developed in geophysics, has recently been applied to produce high-resolution and quantitative reconstructions in the context of medical ultrasound imaging. However, even though FWI has shown great promise, realistic acquisition conditions introduce a series of uncertainties that cannot be fully considered using existing schemes. This could lead to a degradation of resolution and accuracy, and even make the solution of the inverse problem impossible.

One such sources of uncertainty is related to the behaviour of transducers. Existing schemes make strong assumptions on their behaviour, frequently considering them to be point-like, while also neglecting their inherent electro-acoustic response. Here we extend traditional FWI algorithms by using a technique for the characterisation of transducers that ensures a highly accurate modelling of their response. Subsequently, we explore the impact that uncertainties in transducer behaviour have on the resulting reconstructions.

Methods

The proposed technique extends traditional FWI schemes through the addition of a secondary optimisation problem whose aim is to find a suitable transducer model from measurements while honouring the full wave equation. This leads to transducer models that are well suited for FWI, as well as other techniques such as optoacoustic tomography, in which close agreement between experimentally acquired and numerically modelled data is needed.

The technique is validated on experimental measurements acquired using disk transducers of different diameters, with and without lenses. We then compare the results in terms of errors in magnitude and phase with those obtained using common transducer modelling approaches: neglected response, deconvolution and holography/backpropagation.

The impact on FWI of uncertainties in transducer behaviour is explored using a numerical phantom of the human head by comparing the quality of the reconstructions when transducer response is correctly or incorrectly modelled.

Results

Figure 1-A to C suggest that a high degree of certainty on the transducer response is needed for FWI under realistic acquisition conditions. When compared to commonly employed transducer models, Figure 1-D and E confirm that the proposed technique can achieve superior transducer identification performance.

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