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Active Noise Tomography in Medical Ultrasound

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We propose a translation of widely-used seismic ambient noise tomography to active noise tomography in medical ultrasound. This is intended to eliminate time-consuming transducer calibration and to improve illumination of the target.

Ultrasound computed tomography (USCT) is an emerging visualization modality in medical imaging and is especially apt to screen soft human tissue such as the breast. Currently, USCT applications are developed for breast cancer detection using a collection of ultrasound scans that measure the pressure wavefield emitted by individual transducers. To obtain good coverage, a large number of emitter-receiver pairs is required, as well as careful calibration of transducers using reference measurements in water at constant temperature. Standard acquisition and calibration are time consuming processes, placing major constraints on the integration of USCT for breast cancer detection in medical practice.

We present a novel approach to obtain traveltimes between transducer pairs in USCT by applying random field interferometry, as developed in seismic imaging. Since ambient noise sources are absent in the medical application, we generate random wavefields actively by firing sources in a random sequence. Cross-correlation of the recordings provides an approximation of Green's functions between receivers, from which traveltimes measurements can be extracted.

The proposed method has two major benefits: (1) Since cross-correlation eliminates time shifts caused by the a priori unknown source wavelet, the tedious calibration step can be avoided. (2) Coverage improves because the implicit use of reflections off the device boundary overcomes limited illumination caused by the small opening angle of typical ultrasound transducers.

The traveltimes extracted from the Green's function approximations can be used as new data in a ray-based traveltimes tomography. As a proof of concept, we test the algorithm on numerical breast phantoms, and we show that the latter can be reconstructed successfully from the cross-correlation traveltimes. In summary, random field interferometry opens new perspectives to shorten and facilitate the acquisition and tomographic inversion of USCT datasets.

