Contribution ID: **80** Type: **Poster**

Random field interferometry for medical ultrasound

Ultrasound computed tomography (USCT) is frequently used for medical purposes to image soft tissue body parts, as for instance the breast.

Breast cancer detection using USCT usually works with a collection of ultrasound scans that measure the pressure wavefield emitted by individual transducers. This often requires a large number of emitter-receiver pairs to obtain a good coverage of the domain of interest, and careful calibration of the emitting transducers using reference measurements in water.

We present a novel approach to obtain time-of-flight measurements between receiver pairs in an USCT setup by applying the interferometry principle. By substituting active emitters with virtual ones, specific source imprints are eliminated, thus avoiding the need for reference measurements and calibration. Using interferometry and virtual emitters, we retrieve Green's functions between any two measurement locations, which can be used as new data for the inverse problem. The proposed method gives new perspectives to shorten the acquisition time of an entire USCT data set as well as to increase the data coverage.

We perform numerical experiments using a phantom representing a 2D cross-section of a breast and include some variations in the speed of sound inside the phantom to model regions with malignant cells. Using cross-correlations and stacking of A-scans, we show that one can extract the travel time between any pair of transducer positions from random wavefields, created by a superposition of individual source wavefields. Those data are then used in a time-of-flight inversion to reconstruct the speed of sound of the breast phantom.

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Session Classification: Poster Session

Track Classification: Poster Session