Contribution ID: **43** Type: **Oral**

3D time-domain spectral-element ultrasound waveform tomography

Wednesday, November 1, 2017 11:20 AM (20 minutes)

Waveform inversion for ultrasound computed tomography is a promising tool to image the acoustic properties of breast tissue. We present a technique for time-domain 3D acoustic waveform inversion that combines the spectral-element method with source encoding strategies and a quasi-Newton trust-region method. The key objective is to reduce the computational cost of waveform inversion by randomly encoding the emitters in space and by introducing time lags based on the acquisition geometry.

(2) Material and Methods

The spectral-element method is a high-order numerical scheme to efficiently simulate the wave equation. Our approach combines source encoding strategies with a special implementation of the so-called "lazy spectral-element method". In addition to randomly encoding the transducers in space to emit simultaneously, we introduce time lags to overlap the simulation in time. This method dynamically adjusts the computational domain and computes the wavefield only inside the region of influence of the emitting transducers intersected with the domain of dependence of the receiving transducers. We combine this approach with an adaptive trust-region method based on the LBFGS approximation of the inverse Hessian to image the acoustic properties.

(4) Discussion and Conclusion

We present a novel approach to reduce the computational cost of 3D time-domain waveform inversion with a large number of ultrasound scans. We combine the spectral-element method with source encoding strategies that overlap the simulation of multiple events in time. Numerical results for a synthetic phantom demonstrate that this approach is well suited for typical acquisition geometries in USCT and significantly reduces the computational cost of the recurring simulations of the wave equation.

(3) Results

We demonstrate how the geometry of a scanning device can be modeled accurately with conforming hexahedral meshes by extending a cubed sphere approach. This is a prerequisite for employing the spectral-element method. By overlapping the simulation of multiple scans in time we can reduce the computational cost by up to 40%.

Furthermore, the trust-region method is well suited for adaptively changing the encoding weights and the number of sources during the inversion.

We analyze different misfit functionals and regularization terms and their ability to reconstruct the acoustic properties of breast tissue. All numerical experiments are carried out with Salvus, a high-performance package for full-waveform modeling and inversion.

Author: BOEHM, Christian (ETH Zurich)

Co-authors: Prof. FICHTNER, Andreas (ETH Zurich); Dr JOVANOVIC BALIC, Ivana (SonoView Acoustic Sensing Technologies); KORTA MARTIARTU, Naiara (ETH Zurich)

Presenter: BOEHM, Christian (ETH Zurich)

Session Classification: Session 2: Imaging and inversion II

Track Classification: Main Track