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Towards ultrasound full-waveform inversion for in-vivo whole-body slice imaging of a mouse

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We present current work towards a comprehensive full-waveform reconstruction using in-vivo ultrasound data of a mouse. The data was acquired with a trimodal transmission-reflection optoacoustic ultrasound imaging platform \cite{Lafci} that allows for the joint imaging of optical absorption, ultrasound reflectivity and speed of sound of the tissue. The measurement device consists of a cylindrical array of 512 transducers that collect reflection and transmission ultrasound data. The band-passed filtered data between 0.5 MHz and 6 MHz contains enough low frequency components that can be used in a full-waveform inversion (FWI), which is a powerful imaging technique to create high-resolution models of tissue and bone structure using non-invasive ultrasonic measurements.
The method is capable of using both transmission and reflection data providing quantitative images of tissue parameters such as the speed of sound, density or attenuation, as well as reflectivity images to reveal the shape and location of tissue interfaces.\\
Full-waveform inversion is a non-convex problem, which typically requires an initial model that already captures the acoustic properties of the tissue reasonably well to ensure convergence toward meaningful solutions. To make optimal use of the available transmission and reflection data, we design a multi-stage inversion strategy.
First, we use reverse-time migration (RTM) on a homogeneous initial model to obtain the reflectivity distribution of the tissue structure.
This provides valuable information to fine-tune parameters of subsequent FWI iterations. For instance, it can be used to define a region of interest and space-dependent regularization.
We then perform a time-domain visco-acoustic full-waveform inversion using the spectral-element method to discretise the wave equation.
To promote relevant information such as the separation of reflected and transmitted waves, we employ different strategies to pre-process and select data and to compare synthetic signals with measurements.
Since the cost per FWI iteration is proportional to the number of emitters used, we implement source-encoding as a sampling strategy, which allows us to use the superimposed wavefield from simultaneous emitters directly in an inversion and therefore reduces the number of wave propagation simulations that need to be computed.
Lastly, the quantitative model of the sound speed and density distribution provided by FWI is used to obtain a refined reflectivity image with RTM.
This combination of reflection and transmission information is crucial for further processing steps such as segmentation and classification.

Preferred Contribution Type

Presentation

Authors: ULRICH, Ines (ETH Zürich); Dr KORTA MARTIARTU, Naiara (University Bern); Dr BOEHM, Christian (ETH Zürich); Mr LAFCI, Berkan (ETH Zürich); Mr DEAN-BEN, Xose Luis (ETH Zürich); Prof. RAZANSKY, Daniel (ETH Zürich); Prof. FICHTNER, Andreas (ETH Zürich)

Presenter: ULRICH, Ines (ETH Zürich)