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ADMM-based full-waveform inversion (FWI) for photoacoustic tomography (PAT)

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This study deals with methodological development in photoacoustic tomography (PAT). PAT aims at recovering spatially varying absorption coefficients (AC), which act as an internal passive source induced by electromagnetic radiation. The acoustic waves that are triggered by this source are recorded by acoustic sensors surrounding the target and can be inverted to reconstruct the AC. In this study, we recast the AC reconstruction as a source location problem that is tackled by the so-called nonlinear full-waveform inversion (FWI) method. We design a robust and computationally-efficient formulation of FWI in the frequency domain with the alternating direction method of multipliers (ADMM). The ADMM-based FWI relies on an augmented Lagrangian function, which depends on the wavefields, the sound of speed (SOS), the ACs and the Lagrange multipliers. ADMM solves this multivariate problem iteratively with alternating directions for primal variables (wavefields, SOS, and ACs) and dual variables (Lagrange multipliers) until convergence. The practical implementation of this procedure raises however two major issues. First, the SOS model cannot be reconstructed from the photoacoustic source alone due to insufficient illumination and hence cannot be processed as an optimization variable. Therefore, we need a good apriori knowledge of SOS to reconstruct AC. Second, the ill-posedness of PAT prevents assigning a degree of freedom to each sample discretizing the medium. To overcome the later issue, we design a parsimonious parametrization of the ACs by finding regions with equal AC from the segmentation of the SOS map. By doing so, we end up with an ADMM loop that embeds two least-squares problems for wavefields and ACs. First, the ACs are kept fixed, and the wavefields are reconstructed with a data assimilation. Then, the wavefields are kept fixed, and the ACs are updated when a total-variation regularization is applied to tighten the search space of the problem. One difficulty with the proposed algorithm is the requirement for a good approximation of the SOS model. To address the first issue, we propose to build the SOS and intrinsic attenuation a priori by applying another ADMM-based FWI on an ultrasound dataset obtained by sending and recording acoustic waves from the device surrounding the target. The numerical results on a neonate head model show significantly better results than classical time-reversal algorithms.

Preferred Contribution Type

Presentation

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