A variational method for PhotoAcoustic Imaging Sound-Heterogeneous Media.

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Abstract: The standard approach for photoacoustic imaging with variable speed of sound is time reversal, which consists of solving a well-posed final-boundary value problem for the wave equation backwards in time. We present a gradient based approach which consists of the iterative Landweber regularization algorithm, where convergence is guaranteed by standard regularization theory, notably also in cases of trapping sound speed or for short measurement times. We formulate and solve the direct and inverse problem on the whole Euclidean space, which is common in standard photoacoustic imaging, but not for time reversal algorithms, where the problems are

considered on a domain enclosed by the measurement devices. We formulate both the direct and adjoint photoacoustic operator as the solution of an interior and an exterior differential equation which are coupled by transmission conditions. The former is solved numerically using a Galerkin scheme in space and finite difference discretization in time, while the latter consists of solving a boundary integral equation. We therefore use a boundary element method/finite element method approach for numerical solution of the forward operators. We analyze this method, prove convergence, and provide numerical tests. Moreover, we compare the approach to time reversal.