Reduced Order Model Approach to Inverse Scattering

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We propose a quantitative inversion method for determining the acoustic impedance in highly scattering media based on data-driven reduced-order models (ROM). The ROM is a small dynamical system that we construct directly from the data. It matches the observed data and has a sparse structure of a discretized propagator of the wave equation. The key property of the ROM is that its dependence on the acoustic impedance is very close to linear. Therefore, rather than minimizing the data misfit objective, a popular inversion approach in conventional PDE-constrained optimization, we propose to minimize the ROM misfit. This effectively transforms the highly nonlinear inverse problem to an almost linear one that can be solved in a few iterations if not in a single one. Such formulation avoids the complications of the conventional optimization approaches that are prone to getting stuck in local minima. Moreover, we demonstrate in the numerical experiments that our approach achieves better reconstruction quality.