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Detection of Voids and Cracks with Mono- and Multi-Parameter Full Waveform Inversion

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Full Waveform Inversion (FWI) is a tomography technique with its origin in seismic exploration [1]. Recorded wavefields reveal information about the interior material of a structure. The fitting of simulative to experimental data leads to a high-dimensional, non-linear optimization problem with a computationally expensive forward problem. This usually requires using a gradient-based optimization algorithm in combination with an adjoint method.

In the recent years, mono- and multi-parameter FWI have been applied successfully to detect material perturbations in wave speed and density in non-destructive testing [2,3]. However, detecting voids, such as pores or air-filled cracks remains a challenge. In our work, we propose to use an indicator function as inversion parameter that is zero in the void and one inside the intact domain. Compared to other mono- and multi-parameter FWI approaches our formulation performs significantly better in detecting voids.

First, we consider a one-dimensional example and investigate different ways of modeling the air-filled domain. Then, we show how these effects influence the quality of mono- and multi-parameter full waveform inversion on a two-dimensional scalar wave equation. We discretize the forward problem with linear quadrilateral elements in space and central differences in time. The results show that using an indicator function α leads to the best reconstruction of voids and cracks. Finally, we extend our mono-parameter FWI approach to the three-dimensional elastic wave equation.

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