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# A Faster Full-Waveform Inversion Using Anisotropic Adaptive Mesh Refinements

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Performing a full-waveform inversion (FWI) is a challenging computational task. The method requires thousands of wavefield simulations of either the forward propagating wavefield or the adjoint wavefield. To make FWI cheaper and more feasible the cost of wavefield simulations needs to be reduced. We present a method which can reduce the required computational power for FWI by an order of magnitude by the use of anisotropic adaptive mesh refinements (AAMR).

When smooth velocity models are used in a spectral-element simulation, as is often the case in large-scale seismic wave propagation, the shape of the wavefield is roughly known beforehand. The observation that the wavefield is generally smooth in the azimuthal direction with respect to the source location compared to the radial direction can be exploited in order to optimise mesh design. By using a specific mesh for each modelled earthquake, about an order of magnitude fewer elements can be used to accurately discretise the wavefield compared to the classical approach to meshing where the mesh is designed in a way that a wave of a certain period can travel in every direction. The same mesh is used to model each earthquake in the classical approach.

By using a specific mesh for each modelled earthquake there are a few additional steps needed in the FWI workflow. To begin with, a mesh has to be created for each earthquake and the velocity model has to be interpolated on to each of these meshes. The forward and adjoint simulations are run on each of the meshes and the resulting gradients are then interpolated back from the simulation meshes on to a grid identical to the one where the velocity model is stored and updated. Since the meshes are designed with a single source location in mind, they can not resolve a physical adjoint wavefield as it is made up of multiple source locations. The resulting discrete adjoint wavefield, despite not being a physical wavefield, can however compute accurate sensitivities through correlation with the discrete forward wavefield.

We show working examples that demonstrate that this approach can result in significant reductions in computational requirements while delivering near identical results compared to the classical FWI approach.