Accelerating forward and inverse numerical wave propagation by anisotropic adaptive mesh refinement

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An order of magnitude speed-up in finite element modelling of wave propagation can be achieved by adapting the mesh to the anticipated space dependent complexity and smoothness of the waves. This can be realized by designing the mesh not only to respect the local wavelength, but also the propagation direction of the waves depending on the source location, hence by anisotropic adaptive mesh refinement. Discrete gradients with respect to material properties as needed in full waveform inversion can still be computed exactly, but at greatly reduced computational cost. While the idea is applicable to any wave propagation problem that retains predictable smoothness in the solution, we highlight the idea of this approach with instructive 2D examples of forward as well as inverse elastic wave propagation and demonstrate how meshes can be constructed to 3D global seismic wave simulations.