Data-driver strategy for efficient 3D model-preconditioning FWI

Jean Virieux, Univ. Grenoble Alpes, ISTerre

Full Waveform Inversion (FWI) offers the possibility to extract high-resolution quantitative multi-parameters models of the Earth's subsurface from seismic data. Classically, this data-driven method, which attempts to fit seismo- grams recorded at receivers, is formalized as a nonlinear least-square inverse problem, solved with local optimization algorithms fed with the gradient of the misfit function computed by an adjoint method: see the recent review by Virieux et al. (2017). The discretization of the model space for the FWI reconstruction is generally controlled by the discretization of the forward problem used to solve the visco-elastodynamic partial differential equation (PDE). The required forward discretization is a fraction of the characteris- tic wavelengths inside the medium, while one expects an image resolution from half a wavelength to few wavelengths depending on spatial position and orientation and acquisition design. Consequently, non-stationary and anisotropic smoothing strategies need to be considered on the gradient for suppressing unresolved features or aliasing pattern. In order to implement efficient and flexible smoothing algorithm, we promote a differential ap- proach rather than integral approach. The differential approach is based on the Bessel PDE described by Trinh et al. (2017), directly associated to the inverse filter of the Bessel convolutional filter. The PDE can be efficiently solved with the same numerical method over the same grid/mesh as the wave equation. It can be performed at a fraction of the computational cost of the forward/adjoint problems as shown in Figure 1, and it can be shown that a Laplace filter can be efficiently approximated with a cascaded ap- plication of the Bessel filter. Moreover, one can easily introduce structural and/or quantitative information regarding the expected image of the model, coming for prior expectations. An illustration is given for a 3D subset of the SEAM Phase II Foothill benchmark (Oristaglio, 2012), for which the gradient smoothing based on the prior structural information on local az- imuth and dip values helps moving the model update in the right direction (Figure 2). We shall describe the integration of such smoothing strategy into a general FWI workflow based on a spectral-element method for 3D visco-elastic media.