Elastic FWI: A study on parametrization and applications of the pseudo-Hessian

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Abstract (Font: Arial Bold, 10)

The construction of velocity models for seismic imaging is a fundamental step in the exploratory process, as well as the definition of property and/or reflectivity models containing high spatial resolution that can be used to assist seismic interpretation. Among the various tools available for constructing property models, FWI, or Full Waveform Inversion, has become the Industry's standard for regions of greater geological complexity. As it is essentially a non-linear methodology with respect to the parameters to be inverted, FWI has proven to be a robust tool, capable of reliably estimating propagation velocity models for a wide range of frequencies, which has even led to its use as a substitute for seismic migration through so-called FWI Imaging. However, current uses of FWI are mostly based on the acoustic approximation of the wave equation. Such an approximation is unable to predict wave mode conversions or even correctly predict amplitude variations with offset in rocky media where the elastic wave equation is a more realistic approximation. The output of traditional (acoustic) FWI is also limited to estimates of P-wave velocities, thus preventing a more direct estimate of the elastic properties of the medium directly from the inversion result. The use of the elastic wave equation as a modeling and inversion tool within the FWI flow (Elastic FWI or simply EFWI) allows incorporating elastic effects in the estimation of the wave field and consequently generating synthetic seismic data closer to observed data, although this increase in the number of inversion parameters generates greater complexity, ambiguity, and interference between parameters in the solution. Despite its challenges, the use of EFWI can allow simultaneous inversion of elastic parameters, generating models for P and S velocities, as well as densities. In this study, we show developments associated with EFWI, such as the importance of choosing inversion parameters (Lame parameters, velocities, impedances, and density), scattering patterns and the use of pseudo-Hessian estimates for mitigating crosstalk in multi-parameter elastic inversion. Applications of EFWI in synthetic models representative of pre-salt fields and the equatorial margin are also presented.