ESTIMATING STARTING MODELS FOR FULL WAVEFORM INVERSION USING A GLOBAL OPTIMIZATION METHOD

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ABSTRACT

Full waveform inversion (FWI) has become a popular method to estimate elastic earth properties from seismic data. It is formulated as a data fitting least squares minimization problem, which iteratively updates an initial velocity model with the scaled gradient until a satisfactory match between the real and synthetic data is obtained. The expected imaging resolution is half the propagating wavelength, which makes it the preferred choice for structural interpretations. Advances in high performance computing and improved data acquisition techniques have made FWI feasible on a routine basis. However, the local optimization approaches can converge to a local minimum if the starting model used is not close enough to an optimal model. To prevent premature convergence, multi-scale techniques have been proposed, which build on a low frequency velocity model by successively adding higher frequencies over multiple inversion runs. We propose a two step technique in which we first estimate a good starting model using a global optimization method and then use it for gradient FWI. A global optimization method starts with a random starting model and is not susceptible to be trapped in a local minimum. The starting model for FWI that we aim to estimate is sparsely parameterized and contains a set of interfaces and velocities, which are used to represent the full velocity model. We obtain the depth of the interfaces and the velocities by minimizing the data misfit in the least square sense using a global optimization method like very fast simulated annealing (VFSA). Once the sparse velocity model is obtained from VFSA, we use that as the starting model in a conventional gradient based FWI to obtain the final model. We apply the proposed method to a synthetic dataset and two field datasets from offshore India. The proposed method is able to extract a good quality starting model, which satisfactorily converges to an optimal solution that is in good agreement with well log and observed data.
The true SEG-EAGE overthrust velocity model. 

(a), (b) The velocity model generated after 200 iterations of VFSA using 4 interfaces from a p=0 section. The majority of the velocity model is smooth with a few interfaces. 

(c) The velocity model after 80 iterations of conventional gradient-based FWI with (a) as the starting model.