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A Reflectivity Guided Elastic Full Waveform Inversion
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Full Waveform Inversion (FWI) of seismic reflection data has become a common technique for producing subsurface images based on local minimization of least squares misfit between observed data and calculated model. Usually, an initial model that is close to the global solution of the problem is needed to obtain satisfactory results without being trapped in a local minimum of the misfit function. Due to the limitations in quantity of the observed data, e.g. using seismic traces from surface receivers to make an image of earth model, the full waveform inversion problem is ill-posed and underdetermined. The problem becomes even worse when dealing with elastic waveforms which require increased number of model parameters, i.e. P wave velocity, S wave velocity, density etc. In order to overcome this problem, inserting a priori model information in to the inversion process helps the algorithm to converge to a solution in the vicinity of the global minimum. This kind of information could be included in the gradient of the misfit function by adding model terms, when using conjugate gradient method to iteratively update the model parameters.

On the other hand, producing reliable velocity model is a key for successful Pre Stack Depth Migration (PSDM) of seismic data. Assuming an available depth section of seismic reflection data, e.g. by time to depth conversion of time migrated section, we estimate the P wave velocity from seismic section by first extracting reflectivity and then using Gardner equation (Gardner 1974) as stated by Hondori et. al 2013. This will produce a P wave velocity model which is used in full waveform inversion as a priori information. Our frequency domain elastic full waveform inversion is developed using finite difference method and perfectly matched layers are used on the boundaries of the computational area. A preconditioned conjugate gradient method is used together with improved pseudo Hessian matrix for updating the model parameters. At each iteration the gradient is calculated using adjoint state method, and then l_2 norm of the model term is added to the gradient to constrain the inversion. We suggest that this method not only improves the full waveform inversion results, but also resulting FWI models provide a good velocity model for pre stack depth migration of seismic data.

References

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