Full waveform inversion with elastic scattering theory

*Keisuke Teranishi[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1.Graduate School of Engineering, Kyoto University

The waveform analysis is a powerful tool to investigate the physical properties at high resolution in the areas of interest. Since the wave propagation is influenced by all elastic parameters, it is necessary to include these parameters in the inversion. On the other hand, multi-parameter FWI is a challenging problem because plural elastic parameters increase the dimension of the solution space, in other words the desensitization of each parameter occurs. Some authors used a preconditioned gradient method based on approximate Hessian that takes both the radiation pattern that is dependent on each parameter and geometrical spreading into account in order to discriminate the influence of parameters that could relax the desensitization. However, such methods need to solve so many forward calculations that the computational becomes costly. We suggest a new preconditioned gradient method that seeks preconditioning operator derived from a seismic scattering theory instead of applying many forward calculations to reduce the desensitization.
We incorporate a preconditioning operator of each kinematic parameter, i.e., either of two Lame constants or density based on the scattering theory in 2D frequency-domain FWI. We conduct numerical experiments to compare the results using the new method with those from a conventional method. A single anomaly model with one anomalous block and a model with two anomalous blocks with different anomalous values are used to confirm the performance of the new method and the crosstalk among the kinematic parameters. These results show that our new method could estimate the desired parameter values and minimize the cross-talk. Moreover, complex structure models with free a surface are also used to evaluate the capability of the method in more realistic data that includes the surface wave. Results of our method show that the new preconditioning method could estimate the anomaly in the deeper part of the model because of the sensitivity that is increased after the reduction of the influence of the surface waves. All results indicate this method is advantageous in respect to both the reliability in the estimation and the computational efficiency over the conventional techniques.

Keywords: Full waveform inversion, scattering theory, Preconditioning

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