SVD FOR ELASTIC INVERSION OF SEISMIC DATA

Ilya Silvestrov and Vladimir Tcheverda

Laboratory of Computational methods of Geophysics, Institute of Petroleum Geology and Geophysics, Russia. e-mail:SilvestrovIY@ipgg.nsc.ru

An inverse problem of elastic parameters determination using seismic data is dealt with. A common approach is to consider it as a nonlinear operational equation whose right-hand side is a vector of observed data. The operator is governed by elastic wave equation, the vector of sought elastic parameters is unknown. This equation is usually solved in least-squares sense by applying some local iterative minimization technique, for example, conjugate gradient method or Gauss-Newton method. In seismic processing this method is known as full-waveform inversion. It was proposed in early 1980’s and was widely used and developed by many researches. The method seemed to be very promising at first, because it allowed, in principle, to determine, quantitatively, elastic parameters without needing complicated preprocessing. However its application to synthetic and field data exposed its major drawbacks. Particularly, it was observed that there are troubles with determination of low-frequency component of velocity, coupling of elastic parameters, inability to determine some of them, for example density. Recent increase in computational power, broadening of recorded bandwidth, and complication of problems in exploration and production gave a new stimulus for its further development and application in real data processing. Therefore, for developing of robust algorithms and for their correct use, the principal shortcomings of the method are to be taken into account and are to be studied.

Evidently, Frechet derivative of the initial nonlinear operator defines the convergence properties of these processes because it enters into expressions for the gradient of the cost function and into its Hessian. A powerful tool for analyzing this operator is applying the Singular Value Decomposition (SVD) analysis. In current work we apply this analysis to 2D elastic wave equations. We deal with rather simple case of homogeneous background medium, where the linearized operator may be constructed explicitly. We show that even in such simple situation all former drawbacks of the method take place. They may be explained and predicted by structure of singular vectors corresponding to greater singular numbers. These vectors form the stable subspace in model space and define properties of the recovered solution. Moreover by analyzing the condition number of the operator, the required accuracy of input data can be obtained. The results for surface and cross-well acquisition systems will be presented and discussed.

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