Inverse kinematic problem using Chebyshev polynomials

Protasov M.I., Neklyudov D.A.
Institute of Petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia
protasovmi@ipgg.sbras.ru

The tasks of coal seam monitoring and cross-well tomography are inherently three-dimensional. This is because excitation and recording systems are often not confined to a single plane, and detailed geological models (such as those of a coal seam) contain intrinsically three-dimensional contrasting boundaries. Conversely, the velocity variations within these boundaries and the relief of the boundaries themselves can often be accurately described by polynomial functions.

This paper employs a tomographic approach based on representing the velocity model with Chebyshev polynomials [1]. This parameterization significantly reduces the number of unknown parameters compared to standard grid-based representations. This reduction ultimately leads to a more reliable and stable solution to the tomographic problem, which is crucial when working with limited seismic data.

Performing tomography requires two-point ray tracing in three-dimensional models. For 3D problems, the bending method [2] proves to be a much more effective solution for two-point tracing than the shooting method. However, a classical implementation of the bending method does not account for the limited spectrum of the probing signal, which often results in non-physical ray paths and travel times. This paper uses an approach [3] that partially resolves this issue without incurring excessive computational costs.

The tomography method was tested on realistic synthetic data generated from laboratory coal test data. The input information consisted of the recorded first-arrival times of seismic waves measured in a drift along the mined layer. The paper also presents testing results for a realistic cross-well scanning scenario.

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Literature

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