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One-dimensional Marchenko inversion in stretched space

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In acoustic inversion, we aim to retrieve the density and compressibility of an unknown medium from single-sided reflection data by solving a nonlinear integral equation. If the wavefield is known throughout the medium, this equation simplifies as a linear map between the medium properties and the reflection data. We aim to realize such a map by substituting the solution of a Marchenko equation into an integral representation in stretched space.

(2) Material and Methods

To acquire the wavefield inside the medium, we propose to use a Marchenko equation. This equation has recently been derived in order to compute a wavefield at an arbitrary location in the medium directly from a single-sided reflection response. To solve the Marchenko equation in physical space, the propagation velocity of the medium must be known a priori. If we transform the wavefields and medium properties to a stretched spatial coordinate system in which the wave speed is constant, we can solve the Marchenko equation in stretched space instead. This solution can be obtained without any information on the medium other than its single-sided reflection response and can be substituted directly into a stretched integral representation.

(4) Discussion and Conclusion

In conclusion, we have managed to establish a linear relation between the medium properties in stretched space and the reflection data by substituting the solution of the Marchenko equation into an integral representation in stretched space. Our theory is derived for a one-dimensional medium only. In the future, we aim to investigate if this formulation can be extended to three-dimensional media.

(3) Results

By substituting the solution of the Marchenko equation into an integral representation in stretched space, we manage to establish an exact and linear map between the medium properties in stretched space and the reflection data. We demonstrate that this map can be used for linear inversion in stretched space without involving any approximation. Once the medium properties are retrieved in stretched space, they can be converted to physical space, if a model of the propagation velocity is available.

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