PATH-INTEGRAL IMAGING IN DEPTH DOMAIN AND THE GENERALIZED EIKONAL EQUATION

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A new type of seismic imaging, based on Feynman path integrals for waveform modeling, is capable of producing accurate subsurface images without any need of a reference velocity model (Landa, Fomel and Moser, 2006).

Instead of the usual optimization for travel-time curves with maximal signal semblance, a weighted summation over all representative curves avoids the need of velocity analysis, with its common difficulties of subjective and time consuming manual picking. The summation over all curves includes the stationary one, which plays a preferential role in classical imaging schemes, but also multiple stationary curves when they exist. Moreover, the weighted summation over all curves also accounts for non-uniqueness and uncertainty in the stacking/migration velocities. The path-integral imaging can be applied to stacking to zero-offset, and time-and depth migration. In all these cases, a properly defined weighting function plays a vital role, to emphasize contributions from travel-time curves close to the optimal one and suppress contributions from unrealistic curves. The path-integral method is an authentic macro-model independent technique, in the sense that there is strictly no parameter optimization or estimation involved. Applications on synthetic and real data examples have demonstrated that it has the potential of becoming a fully automatic imaging technique, at least for time-domain processing and imaging.

Whether the same principle can be applied to depth-domain imaging is still an important open question. A fundamental problem with depth imaging, compared to time imaging, is that for a given travel-time trajectory through a datum point, it is not clear a priori where the stack should be located in depth. In addition, the travel-time trajectories in depth migration are often non-hyperbolic, so that a multi-parameter summation is needed. Certainly structural environments and seismic acquisition geometries exist for which path-integral depth imaging, or velocity model independent depth imaging in general, will not work. A very simple example is a laterally homogeneous model where imaging using only zero-offset data is attempted.

In Landa et al. (2006), a synthetic example is shown where the background velocity model is a priori known to have a constant-gradient. By repeating depth migrations over a representative range of constant-gradient velocity models and using residual curvature of the common-image gathers in the construction of a weighting function, a high-quality path-integral depth image is obtained. In the current paper, we speculate on possibilities to generalize the path-integral concept to depth imaging with less restrictive assumptions than a constant-gradient velocity. A vital role could be played in this context by the generalized (or velocity-independent) eikonal equation (Ecoublet et al., 2002).

References

Ecoublet P.E., Singh S.C., Chapman C.H. and Jackson G.M., 2002. Bent-ray traveltime tomography and migration without ray tracing, *Geophys. J. Int.*, **149**, 633-645.

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