5D Interpolation and COV Migration: An Ideal Marriage

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Summary

We show that the 5D minimum weighted norm interpolation algorithm can provide a very good approximation to an idealized acquisition experiment in which all traces share exactly the same offset and azimuth, or equivalently, the same inline and crossline offset vectors. Because this pure common offset vector, or "COV", acquisition configuration gives rise to an ideal input data volume for common offset-and-azimuth Kirchhoff prestack migration, we assert that interpolation onto this COV output geometry grid produces a data volume which is optimal for several common downstream processing applications including minimization of sampling-induced migration artefacts on the stack, post-migration AVO, and post-migration AVAZ/VVAZ fracture detection. Moreover, for such applications we assert that there is no need to construct interpolated traces on a surface-consistent output grid comprising well-sampled source and receiver lines; in fact, such a procedure gives rise to a circuitous processing route in which these surface-consistent data must be subjected to a data binning operation whose sole purpose is to approximately simulate the aforementioned idealized acquisition configuration which could have been directly, and more accurately, estimated by specifying a COV target geometry within the 5D interpolation in the first place. Finally, we point out that while it is straightforward to construct a migration processing flow which accommodates this output COV target geometry , we acknowledge several practical reasons which might preclude ready adoption of this interpolation strategy and which might spur the user to instead interpolate data onto a surface-consistent grid.

Introduction

Five dimensional interpolation by minimum-weighted-norm Fourier reconstruction ("5DMWNI") has gained worldwide acceptance as a useful processing tool, and arguably enjoys its greatest popularity in Western Canada. Trad (2009) provides a thorough description of various possible output target geometries onto which the interpolated traces may be cast, including both surface-consistent and sub-surface consistent configurations. Regarding this latter subsurface-consistent class, one possible approach is to interpolate data onto an output grid which is perfectly regularly sampled across the cmp-x, cmp-y, offset, and azimuth coordinates. Assuming that the data set at hand conforms sufficiently to the 5DMWNI algorithmic assumptions so as to permit high quality data reconstruction, then use of 5DMWNI to project the incomplete observed data onto this particular subsurface-consistent output grid represents a very good approximation to a pure common offset and azimuth (or, equivalently, a pure common offset vector or "COV") field acquisition experiment. This COV target output geometry is ideal for common-offset-and-azimuth Kirchhoff migration (followed optionally by processes which require preservation of information across offset and/or azimuth dimensions such as AVO, AVAZ and VVAZ inversion); however, for some reason typical industry practice seems to overlook this fact, and instead demands interpolation onto a densely sampled surface-consistent data grid. Although two excellent recent papers have shown good migrated-domain AVO and AVAZ results using this surface-consistent grid approach (Hunt et al., 2010; Downton et al., 2010), we feel that widespread adoption of the approach represents an unnecessarily circuitous practice, since these surface-consistent interpolated data must be subjected to a data binning procedure (Cary, 1999) in order to form "pseudo COV" volumes which exhibit approximate localization in inline and crossline offset (or, equivalently, in offset and azimuth) in order to achieve the requisite preservation of offset and azimuth information. By contrast, data interpolated directly onto the COV target geometry are naturally indexed by azimuth and offset and may be input to migration without the additional step of pseudo-COV-formation. Moreover, the COV-interpolated data will provide better resolution than their pseudo-COV counterparts unless the source and receiver lines spacings are chosen to be extremely small, a process which can give rise to expensive runtimes and onerous storage requirements. The primary objective of this paper is to demonstrate that interpolation using a COV output configuration represents a more natural, and therefore superior, approach for most common processing applications compared to interpolation using the surface-consistent configuration. We hope that our careful, tutorial style demonstration of COV output configuration superiority allays the current state of confusion within the industry surrounding optimal choice of output geometry for traces constructed by 5D interpolation.

References

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