Effective Computation of Geometric Attributes with 5-D Interpolation

Preconditioning of seismic data by not only removing spatial noise or enhancing the coherency and alignment of the reflection events but by regularizing the missing offsets and azimuths in the prestack stage results in more balanced stacked data and yields confident attribute displays clear of artifacts.

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Usually, 3-D seismic surveys are designed to properly sample the subsurface geometry in all spatial dimensions comprising the two axes (x and y), offset, and azimuth required by our processing algorithms. In reality, missing shots, platforms and other obstacles, and tides and currents that give rise to feathering result in irregular acquisition of marine data. Since the days of the single streamers, the inlines are usually well-sampled, but sampling in the crosslines is usually more coarse. Land acquisition encounters a different suite of obstacles that, coupled with limited recording capacity and greater cost, results in "holes" in seismic data coverage. Recording equipment malfunctions and noise bursts during acquisition may add more missing traces to the usable recorded data.

Sparse or missing data have created problems for the processing algorithms. Early post-stack migration volumes often exhibited aliasing artifacts for poorly sampled data, and prestack migration also has suffered from aliasing. However, the desire to apply prestack inversion, AVO, and AVAz demands regularity in the offset and azimuth dimensions for optimum performance. Geometric attributes, such as coherence and curvature computed from suboptimally sampled seismic data, give rise to acquisition footprint and other artifacts.

According to the authors, the ideal way to fill in the missing data gaps would be to reshoot the data in those areas, but such infill acquisition would be extremely expensive per data point, even if the equipment could be made available for such a small time in the field. Such problems have been addressed at the processing stage since the advent of digital processing, whereby adjacent traces are used to populate the missing values. Initial trace replication was superseded by first 2-D and later 3-D triangular trace interpolation algorithms. These methods, referred to as local methods of interpolation as they need localized information for their operation, are fast and easy to implement but cannot handle large gaps in the data. During the last decade or so, global methods for data interpolation have evolved that use farther well-sampled data to populate the missing data. These methods are multidimensional rather than 1-D, operating simultaneously in as many as five different spatial dimensions, and are able to predict the missing data with more accurate amplitude and phase variations. These methods are compute-intensive and have longer run-times than the local methods.

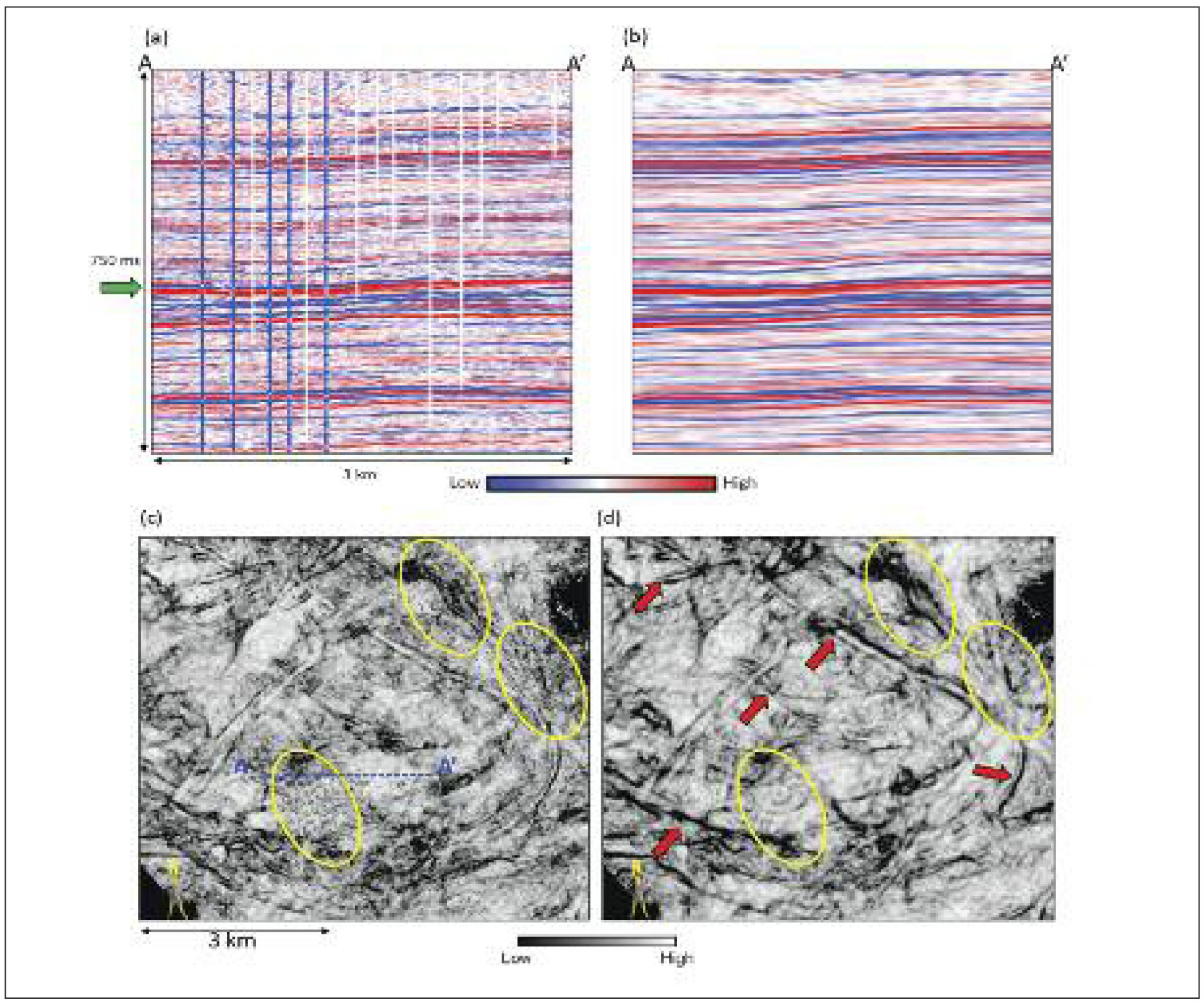

Figure 1: Vertical seismic sections through the seismic volume (a) before, and (b) after 5-D interpolation are shown; horizon slices a few milliseconds above the marker are indicated with the green arrow in Figure 1a. from the coherence volumes computed from seismic data (a) before and (b) after 5-D interpolation. Notice the absence of missing data and the higher signal-to-noise ratio of the data images to the right.
(Image courtesy of Arcis Seismic Solutions, TGS)

Various multidimensional interpolation methods have been proposed by different developers, but this article describes the application of one such approach called the minimum weighted norm application. Figure 1a shows a representative vertical slice through a merged 3-D amplitude volume that has many dead traces. Such dead traces are seen on other inlines as well. The location of this inline is shown in Figure 1c as AA', where a horizon slice through the corresponding coherence volume is shown. The dead traces result in the speckled pattern indicated with yellow ellipses.

To regularize the data, 5-D interpolation was run on the seismic data prior to migration with the equivalent displays shown in Figures 1b and 1d, respectively. Note in Figure 1b that not only are the missing traces interpolated, but the overall signal-to-noise ratio and reflector continuity is improved. Similarly, note the absence of the speckles associated with the missing traces and the greater continuity of the channel and other discontinuity features as indicated by the red arrows (Figure 1d). The inference drawn from this example is that regularization by 5-D interpretation yields better focused images. Interpretation carried out on such attributes will be more accurate than the one carried out on data without regularization, according to the authors.

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