V004 AUTOMATED TRAVEL TIME ESTIMATION

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Introduction

Although prestack depth migration has become a part of mainstream seismic imaging technology, its full application is limited in part by our ability to determine models of the earth quickly and accurately. Most current methods for analysing prestack images and updating the underlying earth model depend upon the complex, global relationship between the model and the moveout on image gathers. However, common focal point (CFP) technology (Berkhout, 1996a,b) breaks the model determination process into two simpler processes, operator estimation and tomographic inversion, which can both be automated,

Method

Our approach to automated travel-time estimation is local and starts from an initial estimate of a travel-time operator, and iterates between generating a CFP gather using the operator and updating the operator from the gather until our convergence criteria are satisfied (see Figure 1). For a specific point in the image volume, $\mathbf{x}$, a CFP gather can be calculated using the following Kirchhoff implementation:

$$CFP(\mathbf{x}_s, \tau; \mathbf{x}) = \int d^2\mathbf{x}_r I(\mathbf{x}_s, \mathbf{x}_r, t = \tau + T(\mathbf{x}, \mathbf{x}_s) + T(\mathbf{x}, \mathbf{x}_r)),$$

where $\mathbf{x}_s$ and $\mathbf{x}_r$ are the source and receiver surface locations, respectively, for an input trace $I(\mathbf{x}_s, \mathbf{x}_r, t)$, and $T(\mathbf{x}, \mathbf{x}_s)$ and $T(\mathbf{x}, \mathbf{x}_r)$ are the travel times from the focal point $\mathbf{x}$ to the source and receiver, respectively.

If the correct travel-time is used, the CFP gather is flat at $\tau = 0$, and summation of these samples yields a single point in the migrated image. However, a small error in the travel times yields a corresponding opposite error on the CFP gather, with the correct travel time lying approximately halfway between the two (Berkhout, 1996a,b). Consequently, we can automatically generate an updated operator by picking and tracking an event on the CFP gather and averaging it with the operator used to construct the gather. When the gather is flat within our tolerance, the error in the operator is approximately half the tolerance and the process has converged.

We tested our method on the 3-D SEG/EAGE overthrust model, starting with a constant-velocity travel-time operator, and achieving convergence in just a few iterations (see Figure 2). More examples and details on the method will be given in the talk.

Conclusion

We have successfully demonstrated the automation of travel-time operator estimation. When combined with tomographic inversion, this technology holds great promise for fully automating model determination, resulting shorter time-to-solution for seismic imaging.

Acknowledgements

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Fig. 1: Flow chart for estimating a travel-time operator using CFP gathers. The simplicity of this method can be attributed to CFP gathers and travel-time operators having the same domain as well as the fact that operators for different image positions can be estimated locally and independently.

References

- Berkhout, A.J., 1996a, Pushing the limits of seismic imaging - Part I. Prestack migration in terms of double dynamic focusing, Geophysics, in press.
- Berkhout, A.J., 1996b, Pushing the limits of seismic imaging - Part II. Integration of prestack migration, velocity estimation and AVO analysis, Geophysics, in press.

Fig. 2: CFP gathers for a location in the SEG/EAGE overthrust model. Each plot is a 3-D CFP gather, consisting of a 9 by 9 grid of traces, displayed as a set of constant y-slices, x varying first. The top gather is from an initial constant-velocity travel-time operator. By the 2nd iteration (bottom), the amplitudes have grown dramatically and the median moveout on the gather is equal to the time discretization (4 ms).

V005 TRACE CONTINUITY ANALYSIS FOR STRUCTURE INTERPRETATION — CASE STUDIES ON CARBONATE RESERVOIRS

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Introduction

In order to define accurate reservoir models for the enhancement of the oil production, a methodology of the structure lineament extractions from the 3-D post-stack seismic data is becoming more important, not only for exploration, but also for exploitation. Following the increasing use of interpretation software, which works on the powerful workstation system, structure interpretation has been made easier. However, the fault interpretation still has some difficulties. This is because the fault planes are mainly recognized as the discontinuity of the seismic reflectors. In other words, faults have not been revealed as the numerical fault “surface” to date.

The continuity analysis is a method for identifying faults and stratigraphic features on 3-D seismic data volume by measuring the localized waveform similarity or continuity using cross-correlation techniques with nearest neighbouring traces (Bahorich and Farmer, 1995). This paper describes one of the case studies to examine this method on the heterogeneous carbonate reservoirs.

Methodology

The continuity analysis is a measurement of the similarity for two waveforms (cross-correlation). For two waveforms G_T and H_T , the normalized cross-correlation function ϕ , at time t and dip d within the time window Δt , is as follows (Sheriff, 1991):

$$\phi(t, dt) = \frac{\sum_{T=t-\Delta t/2}^{T=t+\Delta t/2} G_T H_{T+dt}}{\sqrt{\sum_{T=t-\Delta t/2}^{T=t+\Delta t/2} G_T^2 \sum_{T=t-\Delta t/2}^{T=t+\Delta t/2} H_{T+dt}^2}}$$

The computation is repeated for every possible dip in time dt within the search limits, and the highest correlation coefficient value is adopted for the result of the original trace G_T . After expanding this calculation for each adjacent trace both inline and crossline directions, a minimum coefficient value is selected as a representative value of the original trace G_T .

Case study

This is an example of offshore 3-D seismic data acquired from a domal structure. It has