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Data examples of pixel-precise velocity analysis

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ABSTRACT

Velocity resolution is different using the pixel-precise analysis method on field data than using conventional analysis. The spectra do not smear out laterally. However, the signal-to-noise level can be lower.

INTRODUCTION

The process of velocity analysis transforms field data in (x, t) coordinates to velocity coordinates (v, τ) where τ is zero-offset time. Given any three coordinates, the fourth can be determined from them. Claerbout (SEP-65) suggested making v the computed coordinate, because it alone of the four lacks the *a priori* sampling established at data acquisition time. The name "pixel-precise" comes from that the default data space (x, t) sampling is used. This method has interesting consequences in computation cost, interpolation and truncation artifacts, and inverse transformations (Claerbout, op cit.). In this article I examine the results of the forward transformation of field data.

Since any of the four coordinates can be calculated from the other three, this suggests the four velocity analysis methods of Table 1.

Table 1: Velocity transforms

input variables: t, x		output variables: τ, v		
	LOOPED variable (cost)	CALCULATED variable		results
(1)	x, v, τ	t	pull	conventional
(2)	x, τ, t	v	push	fewer artifacts
(3)	x, v, t	τ	push	similar to conventional
(4)	v, τ, t	x	pull	*not studied*

Line 1 is conventional hyperbola summation. Each point in velocity space generates a hyperbola to be summed along in data space. The term *pull* refers to taking a sample

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from data space based on a calculation using velocity space coordinates. *Push* moves a sample to velocity space based on a calculation using data space coordinates.

The pixel-precise method is the same as calculating v (Line 2). It will be referred to as "velocity-push" in this article.

The final method studied in this article is the τ-push method to see whether the push aspect confers similar results to velocity-push.

The computation cost of each method is determined by multiplying the length of the three looping coordinates in Table 1. The velocity-push method has the special property that computation cost is independent of number of velocities used. The "number of velocities" means rounding the calculated velocity to a bin size, then summing together all the data points in the bin to improve signal-to-noise.

PROCEDURE AND RESULTS

Figure 1 shows the resulting velocity spectra—three attributes of three methods. The input gather had a 1970's era cable with 48 offsets. All the output velocities in panels use one hundred velocity increments of equal slowness for a range reasonable in the earth. No smoothing was applied in along any input or output coordinate. All of velocity analyses were performed with the same program and data preparation.

Results

The leftmost panel in Figure 1 shows the number of input points contributing to each output point. The *shape* of the coverage is similar for all three analysis methods, so this shouldn't be an explanation for different results. The *amount* of coverage is lower for velocity-push because of the fixed computation cost mentioned earlier. However, this lower amount doesn't have a major effect.

Raw semblance and mean-weighted semblance are also displayed. Both measure hyperbolic coherency, while the latter takes event strengths into account. The interesting result is the lack of lateral streaks in the velocity-push results. Lateral streaks are caused by the near offset truncation. For involved reasons [2] inner offsets don't contribute as much data to the velocity analysis as the other methods and truncation artifacts are reduced.

[2] The velocity-push v is computed from differences in t and τ. When t and τ are measured at the acquisition sampling interval, a difference of one or more samples will give in a velocity falling below the lowest velocity bin.

Figure 1: Velocity spectra of the same input gather: three attributes of three methods. The count is the samples summed into each output location. The semblance is the mean-squared divided by power. The last column is the semblance weighted by the mean.

Figure 2: Semblance as a function of number of velocities. Same data as in Figure 1. Too few velocities reduce resolution. Too many reduce signal-to-noise. Resampling due to hardcopy plotting distorts these results somewhat.

Effect of the number of velocities

The velocity-push transformation is affected by the number of velocities used. As stated earlier the computation cost does not depend on the number of velocity bins. This means that as the number of bins is increased, the number of data points contributing to each bin decreases and signal quality is reduced. On the other hand, too few bins reduces velocity resolution. The experiments displayed in Figure 2 bear this out. Bins increase by powers-of-two from less than the number of data offsets (48) to many more. The two smaller cases are under-resolved while the last one is low in signal.

Figure 3 graphs kurtosis as a function of number of velocity bins. Curiously there is a minima at near the visual optimum number of velocities viewed in Figure 2.

CONCLUSION

Velocity resolution is different using pixel-precise analysis. The quality of result is affected by the velocity sampling.

Figure 3: Kurtosis as a function of number of velocities. Same dataset and velocity range as earlier figures.

REFERENCES

Claerbout, J.F., 1989, Book Three: Hyperbola tricks: SEP–**65**.