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Short Note

Interpolation, noise suppression, and velocity filtering in 3-D

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INTRODUCTION

In SEP–**73**, Cole and Claerbout (1992) presented a 3-D data interpolation scheme. For each output location, a number of neighboring traces were combined along a best trajectory picked from an estimate of event coherency as a function of 3-D dip.

A somewhat similar scheme is used by Reiter et al. (1993) in 2-D – not as an interpolation tool, but to perform noise suppression and moveout-dependent filtering. Two modifications suggested by this 2-D technique can be used to improve the noise suppression and moveout-dependent filtering capabilities of the 3-D interpolation scheme.

First, the output data are weighted by the semblance (measured along the best dip) as a function of time. While the stacking of the interpolation attenuates noise and events that do not lie along the best-dip direction, typically only a few neighboring traces are used, and the amount of noise suppression is small. The semblance weighting greatly enhances the ability to attenuate energy other than the event that gives rise to the high coherency value.

Second, a median filter is applied along the best-dip direction, rather than the mean of conventional stacking. Because it is less sensitive to outliers, the median will remain unaffected by strong noise bursts on isolated traces.

In this note, I show examples of the noise suppression and velocity filtering power of the new 3-D interpolator. The examples include 2-D synthetics and a real 3-D example, a quarry blast recording from the SEP passive seismic experiment.

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Synthetic examples

A simple 2-D example serves to demonstrate the different methods and their noise suppression capabilities. Figure **??** shows a synthetic dataset containing two dipping events. Random noise with a signal to noise amplitude ratio of 1:1 has been added.

In Figure **??**, the straightforward 3-D interpolation scheme of SEP–**73** is applied. For each output location, we select the N (here N=15) nearest neighbors. Each pair of traces is cross-correlated, and the results are combined to give an estimate of event coherency as a function of dip. The dip which gives the maximum coherency is chosen, and the traces are summed along this trajectory to give a new trace at the desired output location. Although the stack is over fifteen traces, the noise has not been attenuated significantly.

In Figure **??**, the stack is weighted by the coherency, computed as a function of time, measured along the best dip direction. (Actually semblance is being used here instead of the generalized coherency of SEP–**73**.) This weighting supplements the noise suppression power of the stack and makes a cleaner result. In Figure **??**, the median is used instead of the mean, and in Figure **??**, both the median and semblance weight are used. This combination gives the best overall noise suppression.

An example of velocity filtering is shown in Figure **??**. Here we have limited the algorithm to scan over only a certain range of dips; the more steeply dipping event is filtered out. Note that this method does not attempt to deal with the problem of aliased energy.

Real data example

Figure **??** shows quarry blast data from the SEP passive experiment. The 3-D data have been plotted here in 2-D, with the traces sorted by distance from the quarry. The interpolation scheme has been used to filter random noise, and also as a moveout-dependent filter, removing energy with apparent velocities less than 4 kilometers/second. In the processed panel on the bottom, steeply dipping energy corresponding to nearby cultural noise sources has been removed, and the overall noise reduction has made it easier to see several weak near-vertically incident arrivals at late times, corresponding to reflections from layers deep in the crust.

Discussion

Semblance weighting and median filtering have been used to improve the noise suppression capabilities of a 3-D interpolation scheme. Limiting the range of dips scanned by the method also provides a simple way to do moveout-based filtering.

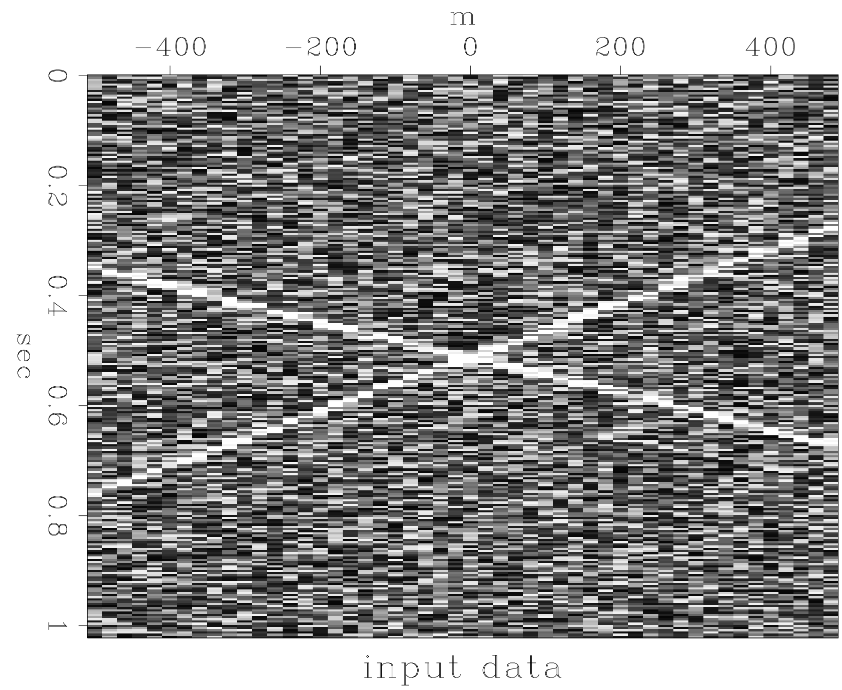

Figure 1: Synthetic example containing two dipping events. Random noise has been added with a signal to noise ratio of 1:1. steve1-noise [ER]

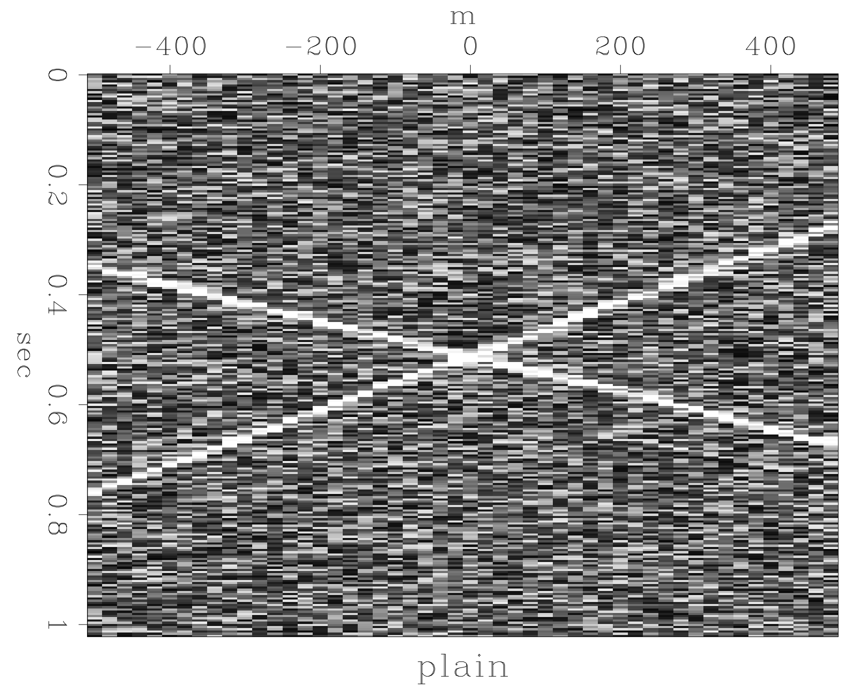

Figure 2: Synthetic interpolated to same geometry to test noise suppression properties. No semblance weighting has been applied, and the mean is used for stacking, so there is little noise suppression. steve1-interp [ER]

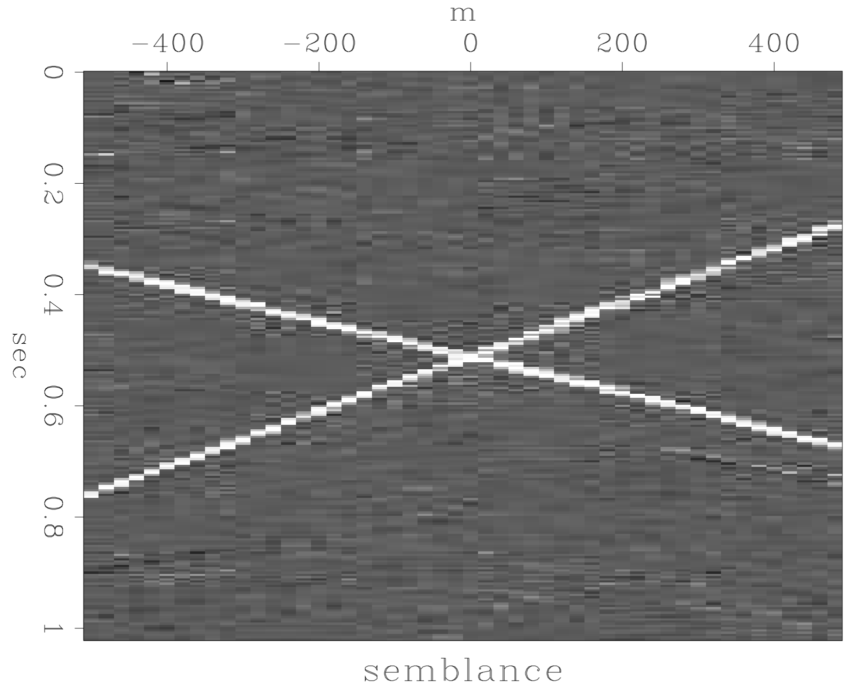

Figure 3: Semblance weighting has been applied. steve1-semb [ER]

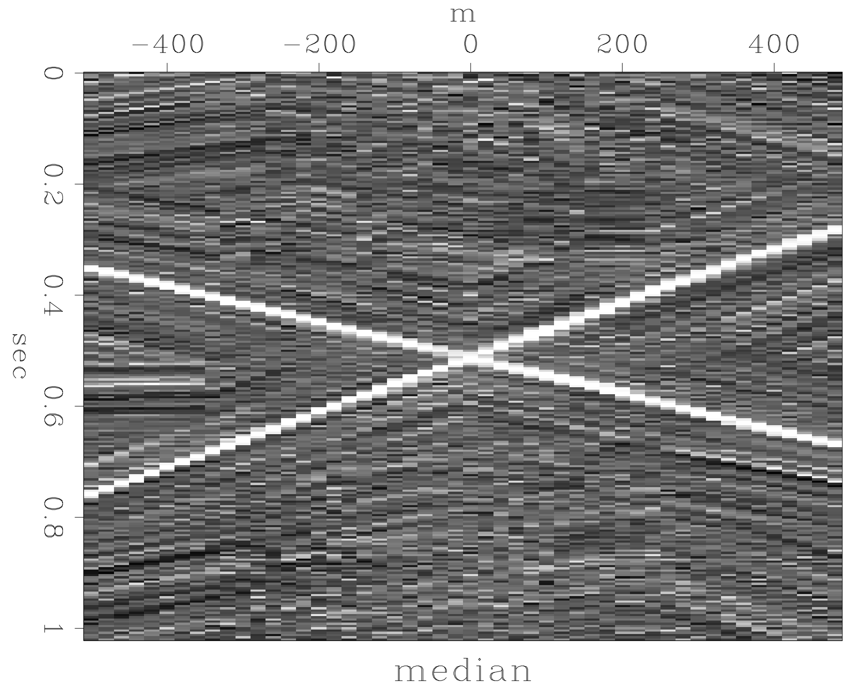

Figure 4: Median filter has been applied along the best dip trajectory, rather than the mean of conventional stacking. steve1-med [ER]

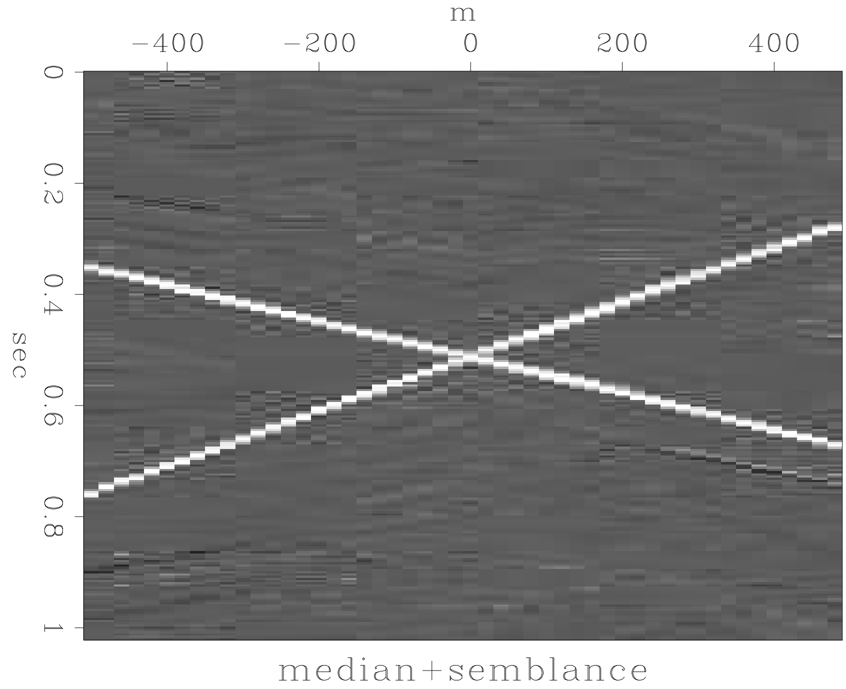

Figure 5: Both median and semblance weighting used. steve1-medsemb [ER]

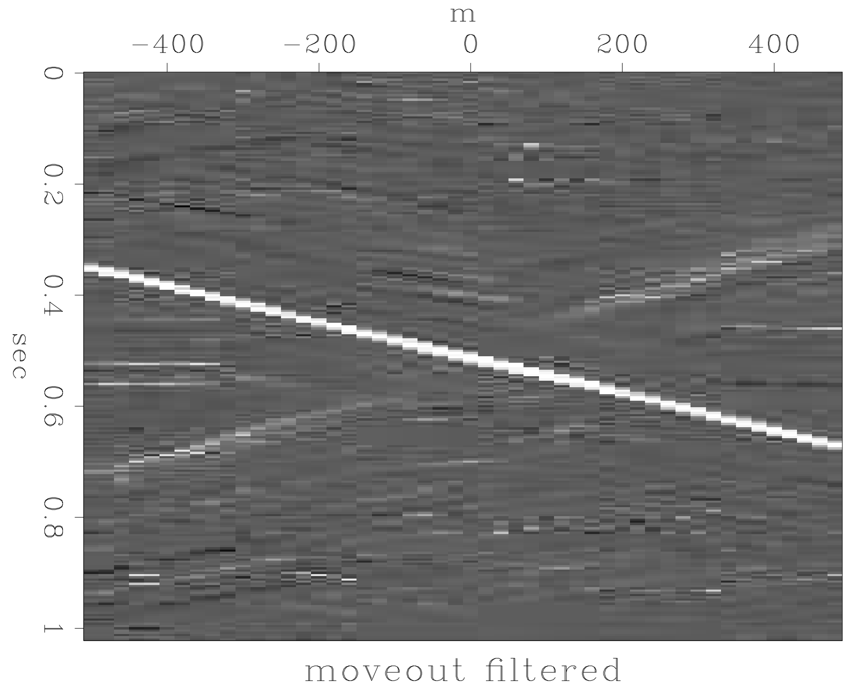

Figure 6: A velocity filtering example. Limiting the range of dips searched by the algorithm can attenuate other dips. steve1-filt [ER]

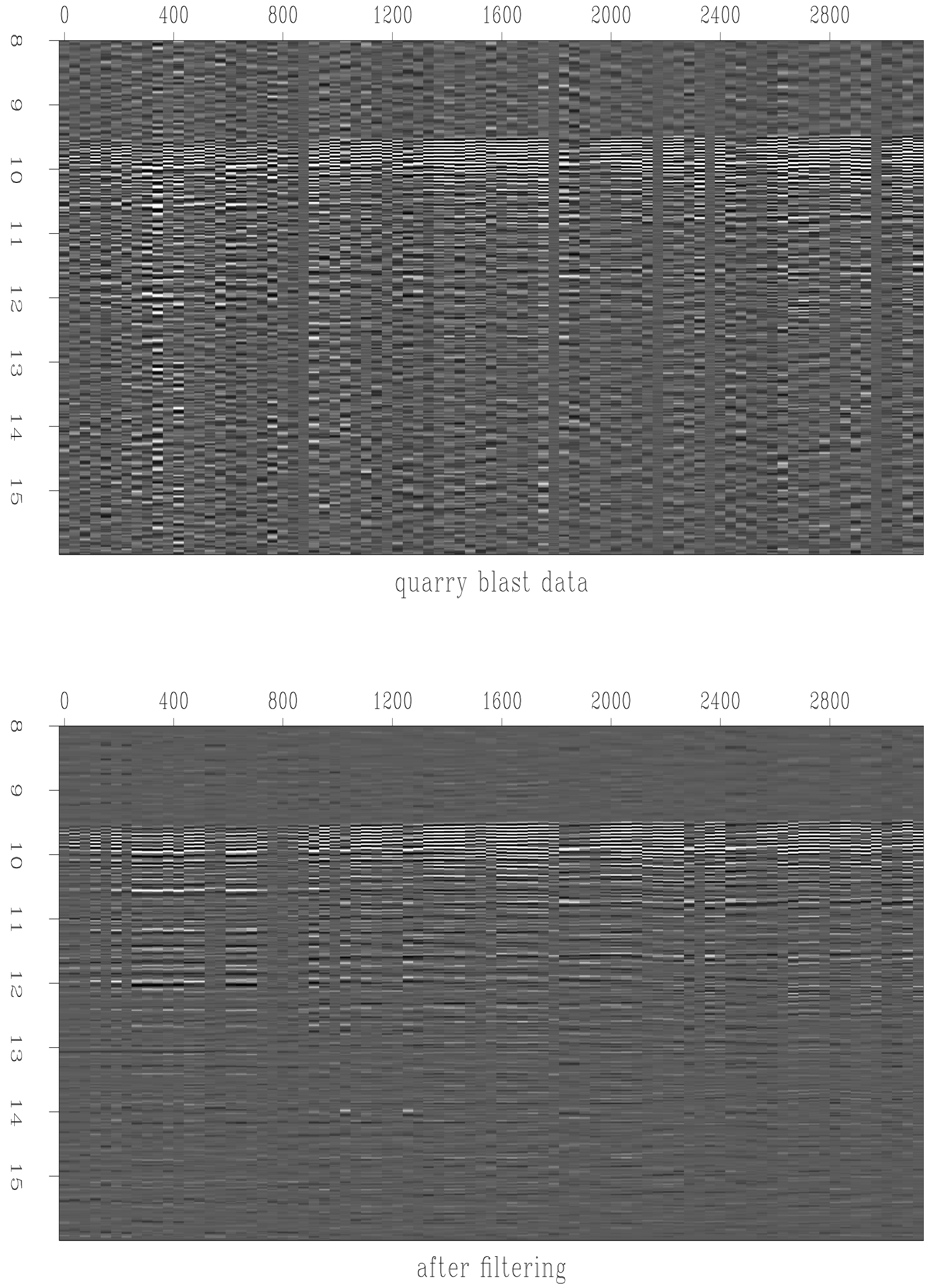

Figure 7: Quarry blast data before (top) and after (bottom) processing to remove random noise. steve1-blastint [NR]

REFERENCES

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