Deblending by asymmetrical multidirectional vector-median filtering

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Summary

Simultaneous source deblending is a challenging process. Low amplitude signal may be interfered with by high amplitude energy such as ground roll or strong reflections from another shot. Data may also contain high amplitude erratic noise. Typical deblending algorithms use a coherence pass filter to create a coherent estimate of the unblended data while ignoring interference, which is incoherent. We use a multidirectional vector median filter operating on receiver gathers as such a filter. To optimize consistency of filtered interfered traces with nearby non-interfered traces it is useful to vary the filter parameters in time and space, depending on the interference times of the trace and its neighboring traces.

Theory

A classic deblending framework (Mahdad, 2012) iteratively subtracts a time adjusted coherence pass filtered estimate of the unblended interfering data from the original blended data to give a new estimate of the unblended data. A multidirectional vector-median filter (Huo et al, 2012) works well as a coherence-pass filter here. The definition of a vector median $\mathbf{X}_m$ is

$$D(X_j) = \sum_{i=1}^{N} \|X_j - X_i\|, X_j \in \{X_i | i = 1, \dots, N\} \quad (1)$$

$$X_m = argmin_{X_j} D(X_j) \quad (2)$$

The vector median is then the vector whose sum of distances to the other vectors in the set is least. In the same way that a scalar median selects the middle value from a set of sorted values, a vector median selects a middle vector from a cluster of vectors. If the vector is a time window of a trace and the set of vectors is the set of corresponding time windows from the neighboring traces, a multidirectional vector median MDVM extends the concept by taking a set of vector medians along a set of trial dips where the corresponding time windows are shifted with respect to the central trace. The MDVM value is the member of this intermediate set of vector medians with the minimum *D* score. It is typically applied in receiver gather domain, each gather sorted by shot line and shot station. Traces are coherent locally in time and space along dominant dips but a trace window with interference will be an outlier. An MDVM filter will find the trace most like the others along some dip while not being influenced by outliers.

It is desirable to use a small spatial trace window, so the estimate of unblended data is as accurate as possible. Especially for ground roll, a high amplitude coherent noise with very high dip, the filter must be accurate to prevent leakage in the subtraction. However, to obtain a good estimate of the unblended data, the filter should be long enough that the non-interfered traces outnumber the interfered traces. One way of reconciling these requirements is to start the search for spatial filter length with three and increase the length. Within each length, it is possible to select spatial windows that are not centered symmetrically. The filter is centered symmetrically and then slid about until all positions have been tested. The search ends when enough non-interfered traces are found, or the maximum allowed length is reached. If no filter is selected, a centered filter of the maximum allowed length is used. This procedure is done at every sample.

Scalar median filters frequently exhibit discontinuities in time. Vector median filters can avoid this difficulty by ramping and summing the median vector considered as a window at each sample, not just selecting the center element of the vector.

Results

We applied our technique to a simultaneous source 3D survey. We processed 5 s. of data so that deep interference noise could be removed from shallow data. The data displayed strong ground roll, interference in the shallow reflectors, and erratic noise. The process restored the unblended data and did not remove signal along with the interference noise. Random and erratic noise was retained. The majority of interference, including interfering ground roll, was removed. The first breaks were cleaned up, allowing automatic picking to proceed easily.

Acknowledgements

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References

Huo, S., Y. Luo, and P. G. Kelamis, 2012, Simultaneous sources separation via multidirectional vector-median filtering: Geophysics, **77**, no. 4, V123-V131.

Mahdad, A., 2012, Deblending of Seismic Data: Ph.D. Thesis, Technical University of Delft, Delft, Netherlands.

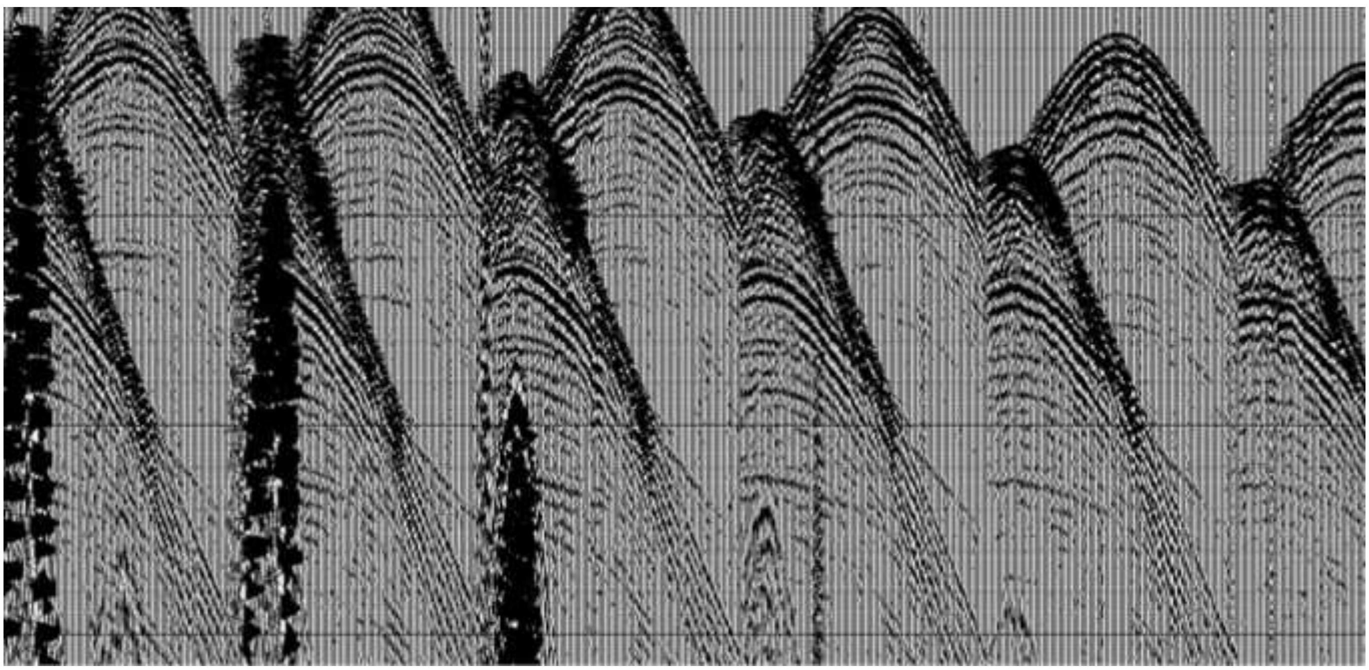

Figure 1. Simultaneous source shot gathers.

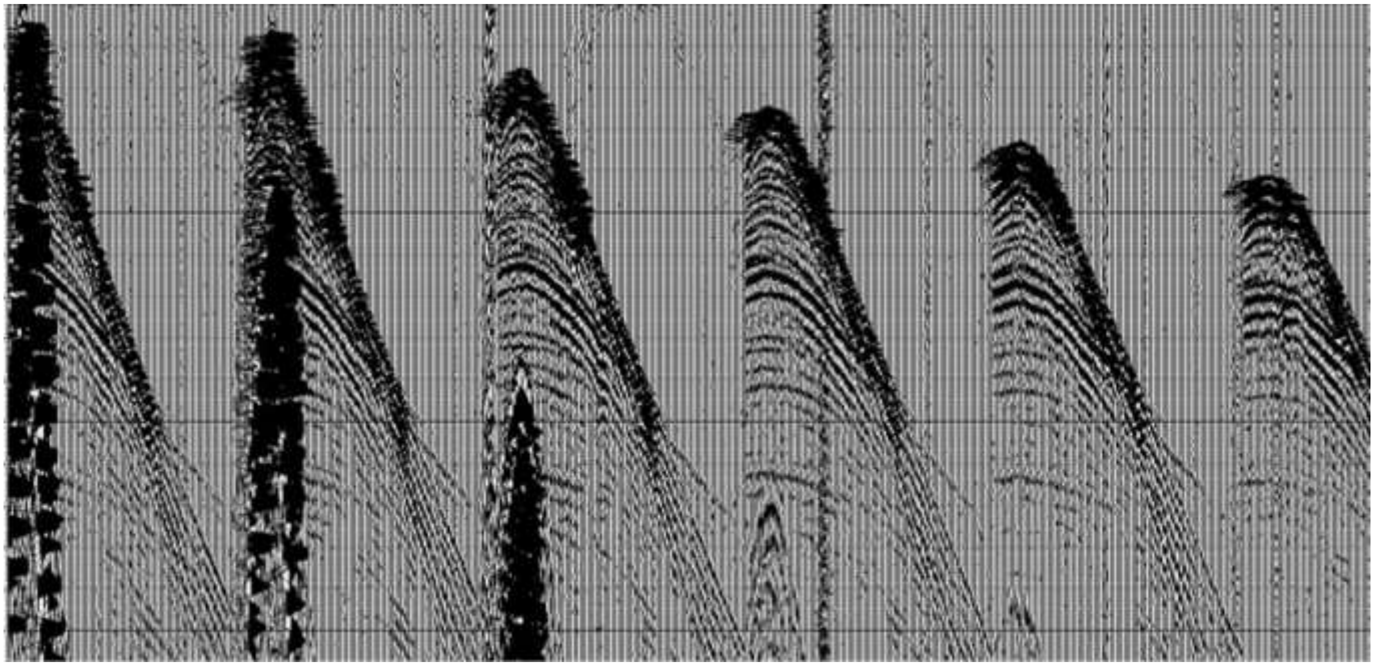

Figure 2. Deblended shot gather

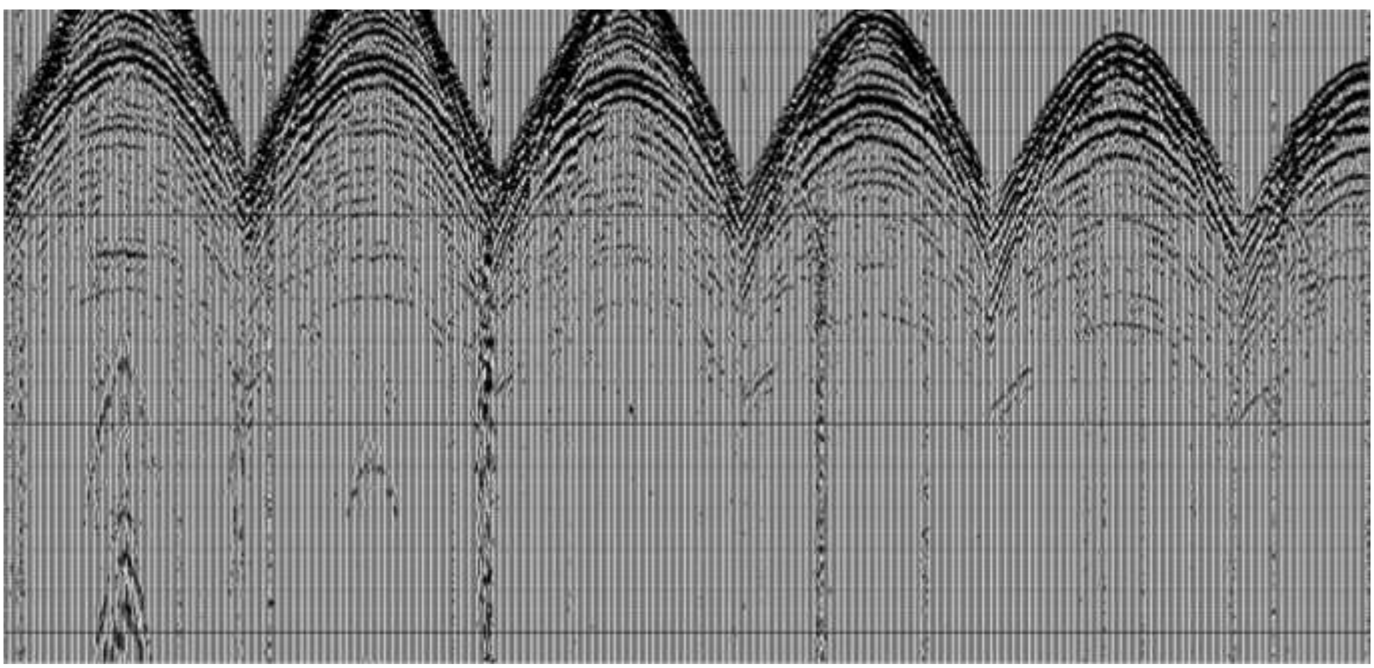

Figure 3. Difference of before and after deblending