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SHAPING FILTERS AS A TOOL FOR EDGE DETECTION

Adelson Santos de Oliveira

PETROBRAS S/A, Brazil

ABSTRACT

This paper discusses preliminary results on the use of shaping-like filters to enhance seismic-image features like edges and/or faults. Shaping filters usually carry information about changes from trace to trace in a seismic section. These changes may be of different kinds. These filters are, in principle, able to gather information about facies, faults and structural changes. However, this paper describes their application in a rather limited and generalized form: each input sample is associated to a value that represents the sum of the squared sample differences between the current shaping filter and a representative one made up as a median of the neighboring filters. This is done in two steps: first in the inline and second in the crossline directions. A final section resulting from the product of the two is shown. This method is a good alternative for identifying structural features.

INTRODUCTION

One can always design a filter that shapes a window of a trace into a window of another trace. Variations of form and phase between these two windows are somehow taken into account by this filter in order to minimize the differences between traces under a given error criterion. The analysis of this filter may help deciding whether variations are in form, phase or some particular combination of them, therefore improving our understanding of the data complexity. In other words, given a particular change in the data, characterized by a related change in seismic amplitude and phase, one can single out this variation with shaping filter analysis. A significant quantitative improvement is expected from the combination of shaping filter analysis, image processing, and artificial intelligence or neural network systems.

This paper presents preliminary results obtained using shaping filters to detect edges and faults. A time slice is shown containing samples of the total square of the difference between a filter and a locally representative filter. This representative filter is obtained as a median of a collection of filters surrounding the sample. This is done in the inline and the crossline directions.

THE SHAPING FILTER ANALYSIS, MOTIVATION AND REAL DATA PRELIMINARY RESULTS

Geometric changes from trace to trace in a seismic section can be classified in two categories: pure shifts, associated with dipping events or faults; and small differences in form. The first category has a shaping filter signature of a spike, displaced from the origin by the corresponding shift in time (or depth) of a dipping event or the throw of a fault. A dipping event is usually broader, in the sense that it encompasses more traces than a fault, thus leading to a constant shaping filter along its area of influence. A fault is characterized by a localized change in time shift, rendering the corresponding shaping filter different from its neighbors. This is the basis for the fault or edge detector method described here. However, as this simple picture of a fault fails these ideas fail too. In fact, a fault is often accompanied by a significant geometric change resulting from either the absence or the inclusion of a portion of data. This yields a more complicated variation in shaping filters than expected. These variations are better recognizable using indicators that consider shaping filters globally. The chosen indicator is a sum of the squares of the differences between a shaping filter and an estimated median of the neighboring filters. The use of the median brings the advantage of not being influenced by nearer faults as compared to the average. For the sake of fault or edge identification, it is advisable to diminish the importance of amplitude variations throughout the section. This is done by normalizing all shaping filters. In addition, the design of shaping filters demands a strategy to deal with ill-posed inverse problems caused mainly by the band limitation of data. Here singular value decomposition (SVD) analysis is used to cope with this problem by considering only the largest eigenvalues.

For the sake of comparison, a time slice in a 3D seismic data cube was extracted from the coherence cube (Bahorich et al., 1995) and from the shaping filter analysis proposed here. Parameters like window length and lateral extension in which the computation was performed were kept constant in both methods. A time window of 100 milliseconds was chosen considering the dominant frequency over the time slice at 2.0 seconds. A three-trace coherence scheme gave better results in terms of delineation of faults when compared to coherence boxes with greater number of traces.

Moreover, the three-trace scheme was closer to the shaping filter procedure that dealt only with the immediate neighbor traces. Results are better compared on the time slice shown in Figure 1, where the seismic line shown in Figure 2 is indicated. Figure 3 shows the corresponding time slice after an inline shaping filter analysis, Figure 4 contains the result of a crossline shaping filter analysis and Figure 5 represents the product of the results in 3 and 4. Figures 6 and 7 show the result obtained with the conventional coherence cube procedure respectively for a three-trace coherence scheme and an eight-trace coherence box. At a first glance, the results indicate better discrimination between faults/edges using shaping filter analysis. This is supported by the virtual absence of coherent information outside the main faulting lines in Figures 3, 4 and 5. A better discrimination of faults in regions A, B, and C of Figure 1 can be observed in Figures 3 and 5 rather than in Figures 6 and 7, although some faults are less defined compared to region B in Figures 3 to 5. One can also notice a smaller influence of acquisition footprints, particularly above region C, on Figures 3, 4, and 5 when compared to Figures 6 and 7. On the other hand, besides faults, the coherence cube method brings extra information that can be related to other interesting seismic features. Nevertheless, it seems reasonable to think of a shaping filter analysis as a sharper, more restrictive procedure than coherence cube studies. It remains for future developments to define indicators other than a global square difference in shaping filter analysis to detect a greater variety of seismic features.

CONCLUSIONS

A preliminary study of a shaping filter analysis procedure for fault or edge detection was presented. This procedure is based on a global filter-variation indicator that allows sharper discrimination of faults in a 3-D seismic data cube when compared to the usual coherence cube analysis. This procedure may be able to identify a fault where the usual method does not, and it also shows weaker dependence on acquisition footprints than the one observed in the coherence cube method. However, other important seismic features are lost in the shaping filter analysis. These features are usually identified by the coherence cube approach and may be as decisive for seismic interpretation as channels and subtle facies changes. Other indicators for a more comprehensive shaping filter analysis can give this method the subtle facies detection skills that interpretation demands. A more comprehensive shaping filter analysis has to be investigated in order to allow detection of other interesting seismic features.

REFERENCES

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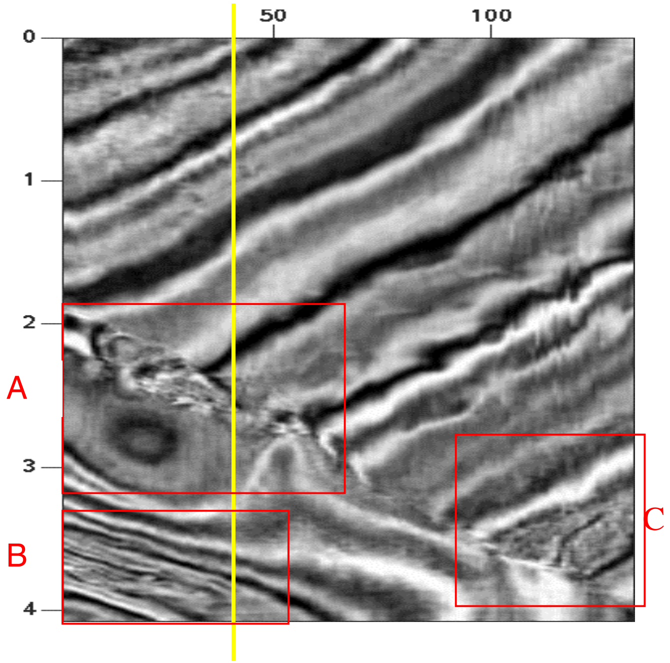

Figure 1 – Time slice along the yellow line on Figure 2. The vertical yellow line here corresponds to the position of the seismic line on Figure 2.

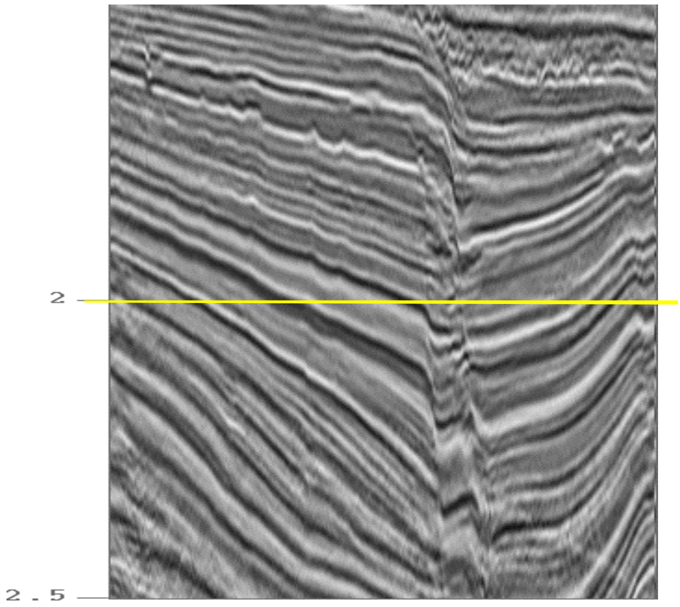

Figure 2 – Seismic line along the yellow line on Figure1. The horizontal yellow line here corresponds to the time slice on Figure 1.

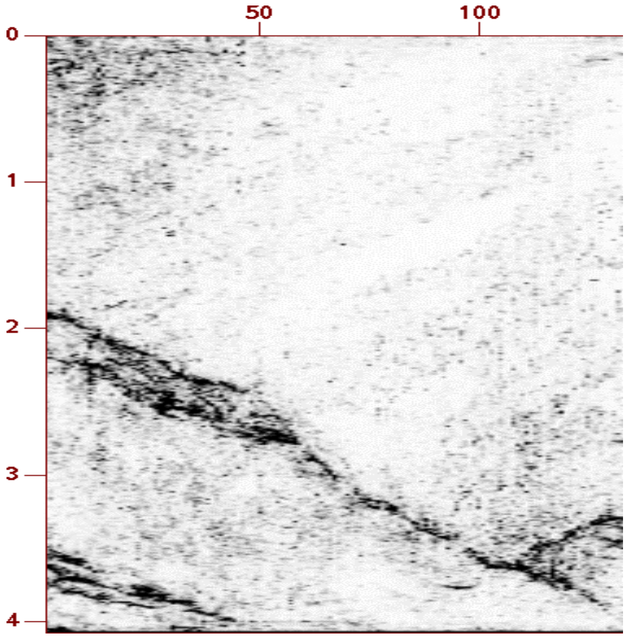

Figure 3 - The same time slice of Figure 1 resulting from the shaping filter analysis in the inline direction.

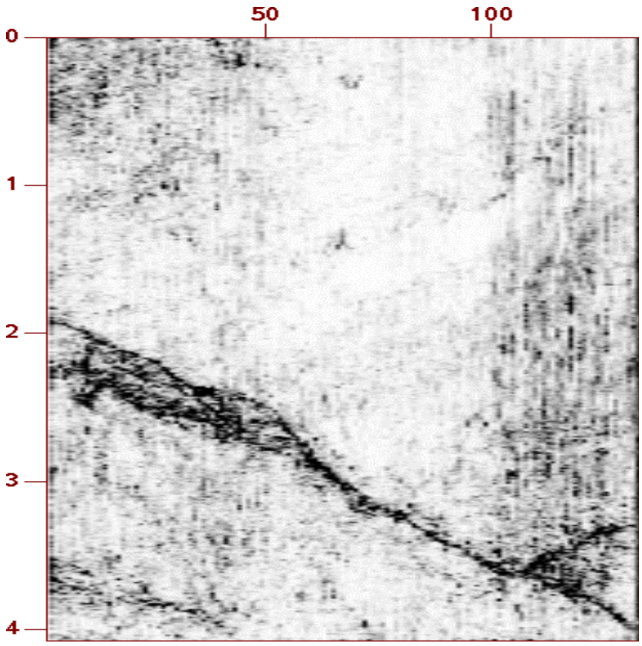

Figure 4 – The same time slice of Figure 1 resulting from the shaping filter analysis in the crossline direction.

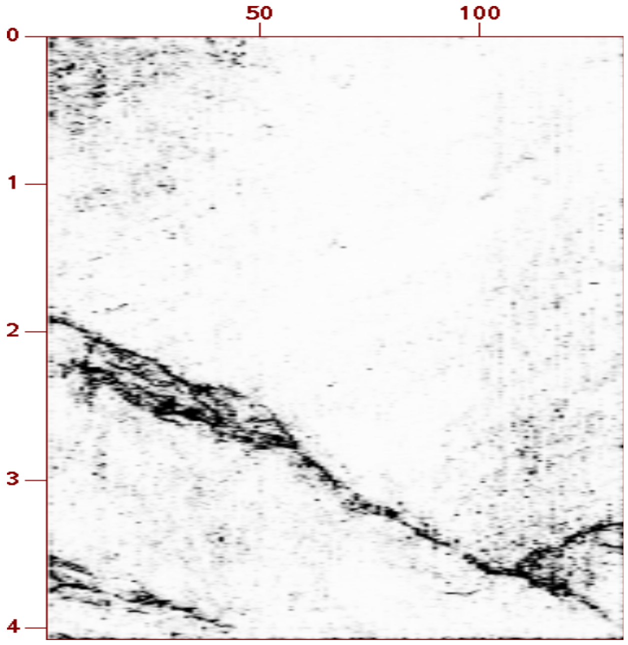

Figure 5 – The same time slice of Figure 1 resulting from the product of the results shown on Figures 3 and 4.

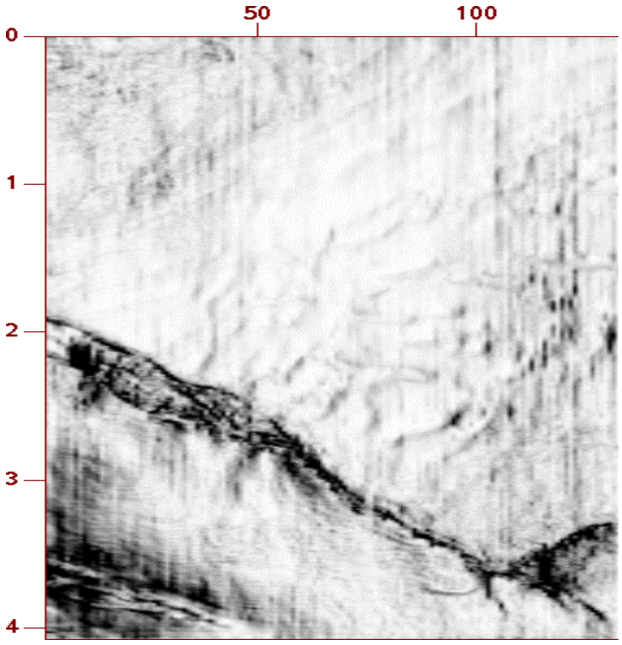

Figure 6 – The same time slice of Figure 1 resulting from the conventional coherence cube analysis using only three traces.

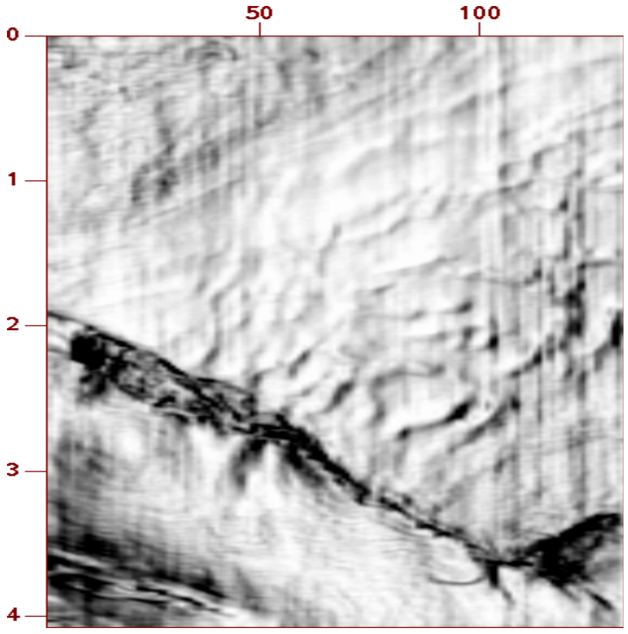

Figure 7 – The same time slice of Figure 1 resulting from the conventional coherence cube analysis using 8 traces.