What's wrong with sharpness

Jon F. Claerbout

ABSTRACT

Sharpness is a measure of the difference between large and small values. Since smearing reduces sharpness, it is often presumed that anything that increases sharpness reduces smearing. Filter design based on maximizing sharpness has many pitfalls. I reinterpret results of Kostov to illustrate them.

INTRODUCTION

People like to report things that work, but are reluctant to report the things that don't. In my case, this means I haven't published something that I know well, namely that "sharpness" is a most hazardous measure of quality. "Sharpness" is any measure of non Gaussianity such as kurtosis or the norm ratio defined by Wiggins. The rush to publishing SEP-51 enabled Clement Kostov to provide an example of the pitfalls of maximizing sharpness.

Kostov

Look at SEP-51, Figure 7 on page 245 which is reproduced here as Figure 1. In panel (a) and panel (b) near the end of the time axis you see two distinct events at 2.05s and 2.15s. On panel (c) after sharpness has been maximized they have become a single monochromatic blur. How can this be? It is not obvious from the plot that the sharpness of (c) really is greater than the sharpness of (a), but I am willing to take the author's word for it, in fact I'll help him make it plausible by saying that the signal level around 1.8-1.9 seconds seems to have been lowered, so if the peak at 1.5 sec is the same, then it is plausible that the sharpness is increased in (c). Since it is obviously bad to blur together the events at 2.05s and 2.15s, what has happened? What has happened in real life is that the small "hole" between the events at 2.05s and 2.15s is really very important to us. It is much more important than the broad depression around 1.6s to 2.0s. The sharpness criterion being used is not clever enough.

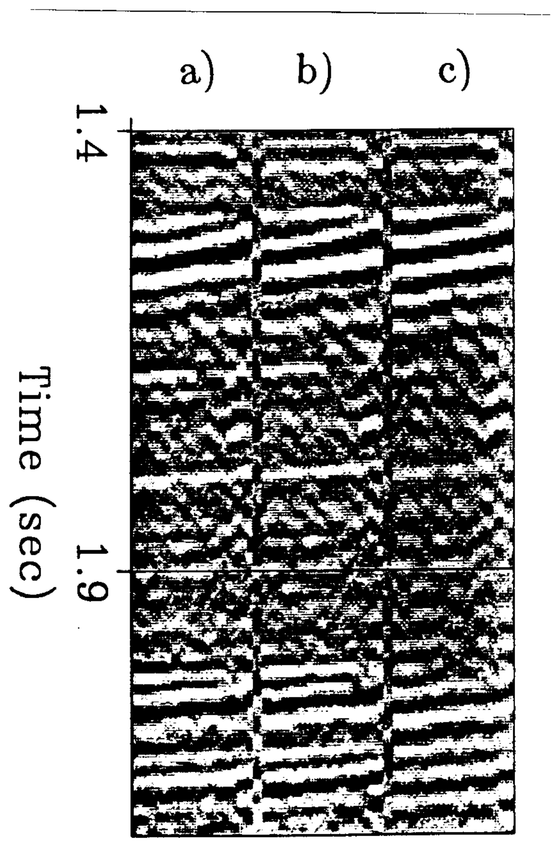

FIG. 1. Kostov's input (left) and output (right).

Harlan

When I raised this difficulty with Bill Harlan he responded by changing his analysis of histograms to an analysis of "local" histograms. Unfortunately, I see no discussion of this difficulty in Harlan's thesis, SEP-47, though I clearly recall the word "local" in his verbal descriptions.

Why sharpness is hazardous

Unlike noise in electrical networks, geophysical signals are always nonstationary, often in subtle ways. Suppose for example the early part of a seismic record contains higher frequencies than the later part. This is almost always so. Then any filter that enhances high frequencies at the expense of low frequencies will boost the beginning at the expense of the end. So the output of any such filter applied to ungained data will boost sharpness. Next consider a seismic record that has initially been time gained into balance. Again, sharpness can be increased by boosting high frequencies. Likewise the opposite applies! Sharpness be increased by boosting low frequencies! The reason is that either of these two opposite strategies will throw the data out of balance on its time gain. And the exasperating thing about it is that neither result is what the investigator wants.

I believe that extremalizing "global sharpness" can always be expected to trip up on the nonstationarity that is always present in seismic data. You can't avoid the need to define *local* statistics.

What is "local?"

Anyone can rescue sharpness as a criterion simply by asserting that stationarity is required. But merely asserting that stationarity is required does not tell you what to do to deconvolve Kostov's data. I guess Kostov's data must be divided into windows, each of which must have its sharpness measured separately, and then all these separate sharpnesses must somehow be combined. How should these local sharpnesses be defined? I don't know. How should they be combined? I don't know. What should be the length of the window? I don't know, but I can suggest two possibilities: One possibility is that the window should be the same as the length of his filter. Assuming that his data is sampled at 4ms and taking the filter length from Figure 6 to be 30, the filter length is .1s, which means about eight windows for the shown time axis. Another possible length for the windows in which to define local sharpness would be the approximate duration of the inverse of the filter in Figure 6. There is no way to estimate this from the figures shown. These two possibilities might give very different results and I don't know which would be better.

REFERENCES

Kostov, C., 1987, Maximum liklihood estimation of residual wavelets, SEP-51 p 235-250

Claerbout, J., 1982, Envelope sensing decon, SEP-30, p 121-131