Cosmetic Enhancement of Seismic Data By Loop Reconvolution

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Introduction

A number of seismic contractors offer high-frequency enhancements of conventional seismic data that assist interpreters in solving particular problems. These methods range from an additional deconvolution step through wavelet extractions to 'black box' proprietary techniques. We present a very simple frequency optimized loop reconvolution method (FOX) which can be implemented quickly and repeatedly (for optimizing visual preferences), and appears to offer many of the same cosmetic benefits as the commercially available techniques.

Conventionally processed poststack seismic data has a comparatively narrow frequency spectrum with the signal utilising only a fraction of the available bandwidth up to the Nyquist. High-frequency enhancements aim to sharpen the data, ostensibly defining structures and pinch-outs more clearly. Irrespective of whether these techniques actually recover any missing or hidden information from the data, they can help with the interpretation because events can appear more sharply defined and are less swamped by the low frequency ringing that characterises conventional seismic data (Figure 1). Interpreters conceptualise the dataset as a sequence of discrete spatially located geological events, whereas data processors emphasise the spatially distributed wavefield and its associated spectral properties. We have developed a process that makes the data appear more like a sequence of discrete horizons with a virtually unlimited bandwidth.

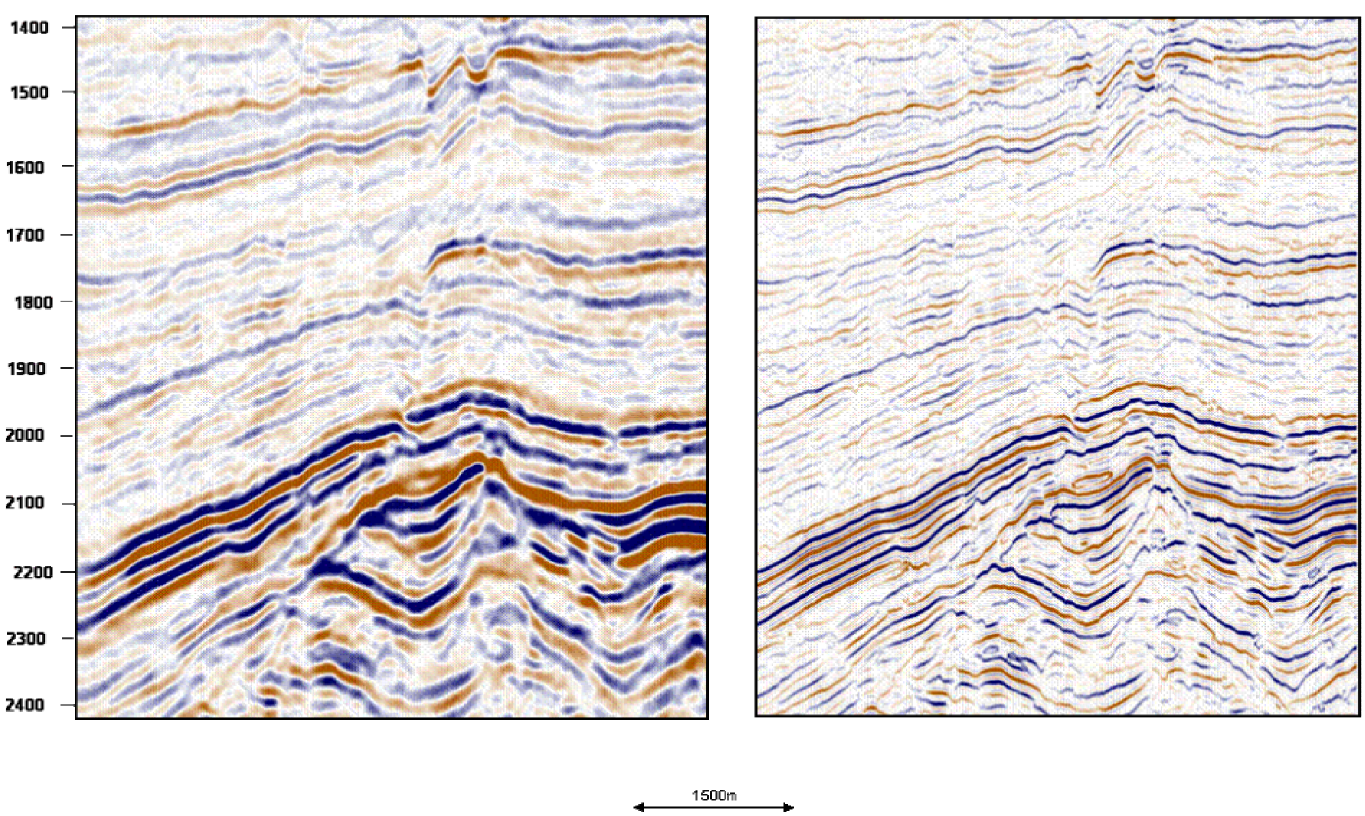

Figure 1. Result of applying FOX (right) to input time data (left).

Method

The method consists of 4 basic steps:

1) Oversample the input SEGY data.
2) Generate a new sparse spike reflectivity series weighted by the interpolated amplitudes at all of the maxima and minima locations.
3) Convolve the resulting reflectivity series with a suitably high frequency wavelet. A broad bandwidth Klauder or other wavelet with smaller sidelobes gives a good result. Visual preferences will determine the optimum frequency band for that dataset.
4) Optional spatial filtering of the final section gives a smoother appearance yet preserves the discontinuities that we are trying to visually enhance.

Most of the individual operations can be implemented using commercially available software packages but the process is cumbersome and slow. For ease of use, we have developed a user-friendly interface that runs our efficient custom code, operating on the data in SEGY format.

Results

We evaluated the FOX cosmetically enhanced data against the conventional input data and a similar looking, commercially available product (Figure 2). Each was subjected to a series of tests including well ties, horizon autopicking, and similarity. The datasets were further evaluated by comparing interpretive features such as faults, pinch-outs and doublets. It is clear that faults are visually enhanced because of the increased number of reflectors that are discontinuous and the broadband wavelet draws the eye to smaller temporal offsets. Similarly, pinch-outs appear more definitive and less tuned, enhancing interpretation. Doublets become discrete events and allow the eye to detect subtle changes in character.

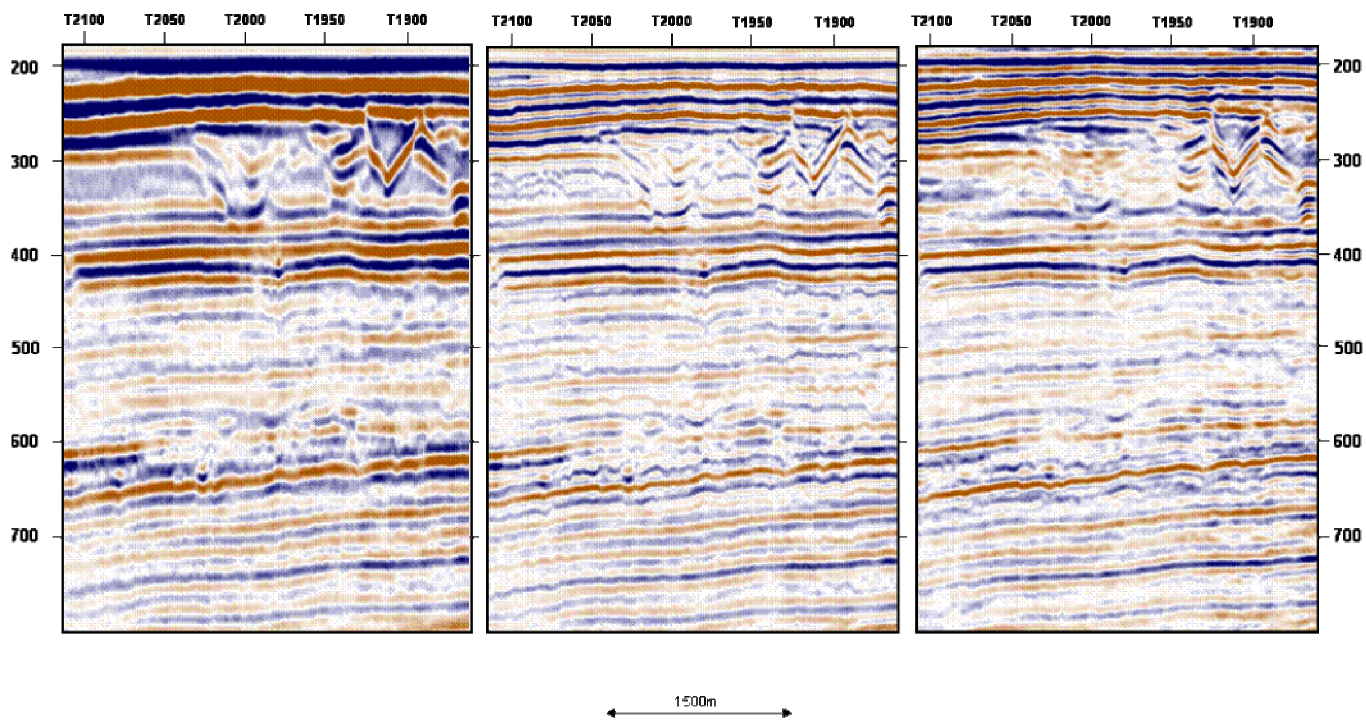

Figure 2. Comparison of input time data (left), FOX (middle) and commercial product (right).

Loop Reconvolution is a true amplitude, zero phase and zero time shift process. This promotes several additional uses for the process on prestack data such as precise alignment and matching of partial offset stacks and AVO analysis. The input of FOX volumes into poststack processes such as ESP offers another perspective on the data that is uncorrupted by amplitude, phase or time distortions (Figure 3).

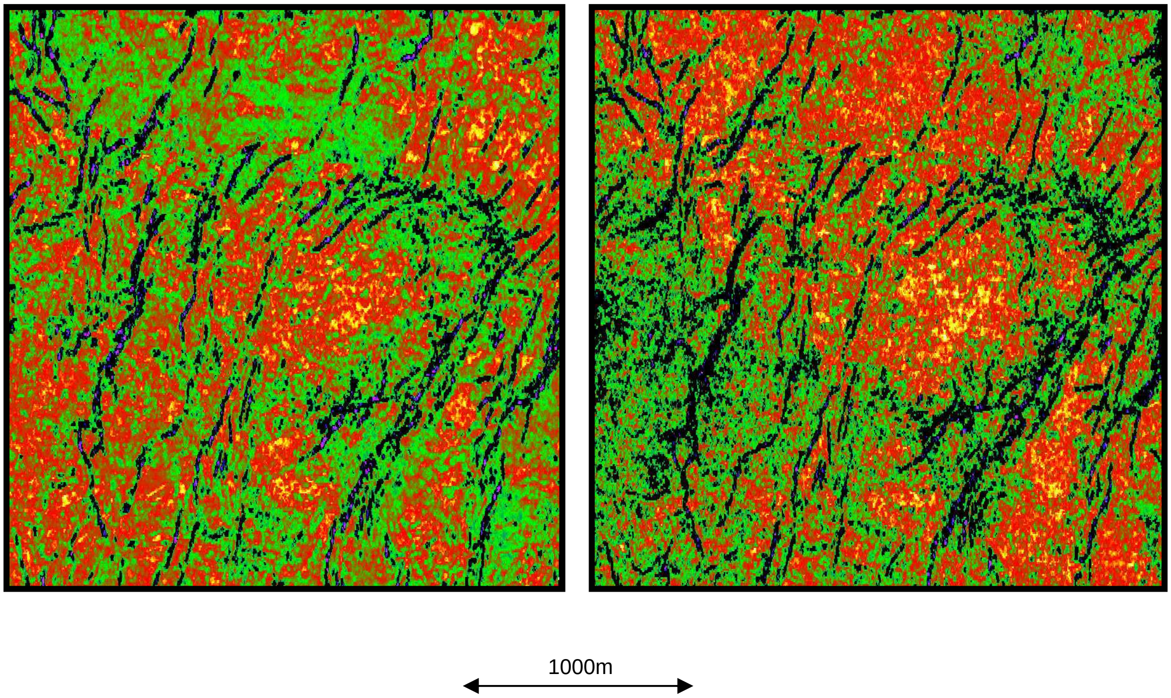

Figure 3. ESP similarity from conventional data (left) and from FOX data (right). Areas of low similarity are in black.