Footprint suppression through the application of the Continuous Wavelet Transform

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Summary

Acquisition footprint manifests itself on 3D seismic data as linear grid pattern noise on a time slice or horizon amplitude. Ideally acquisition footprint should be handled by processors with careful attention (Hill et al. 2009) . Unfortunately this is not an option for vintage post stack volumes where no pre-stack data exits. In this work we explore the use of a modified Continues Wavelet Technique in a bid to suppress the footprint. The method involves decomposing the data slices into voices and magnitudes using filter bank operators. We rely on seismic attribute ability to highlight acquisitoin footprint to design a mask to suppress it on seismic and attribute volumes.

Data

A seismic volume from Vacuum Field, New Mexico, was used for testing purposes in this project. It corresponds to the west Shelf of the Central Basin Platform in Lea County, New Mexico. Figure 1 shows a map with the location of the field around the Central Basin Platform (after Blaylock, 1999). The seismic volume from Vacuum field shows strong footprint in the first 500 ms of data. Figures 2 show a time slice at 450 ms through the seismic amplitude attribute and coherency, respectively.

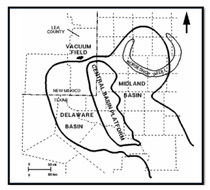

Figure 1: Location map of the Vacuum field (Blaylock, 1999)

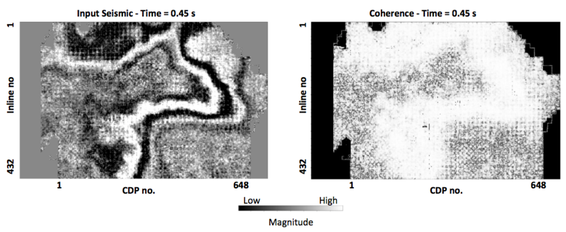

Figure 2: Left: Time slice at 450 ms. Right: Coherence slice at 450 ms.

Theory

Fourier Transform: Following C. Liner (2010), we can define a function $f(x, y)$ in the space domain and its Fourier Transform $f(k_x, k_y)$, which will be linked by the relationship:

$$f(k_x, k_y) = \int_{\infty}^{-\infty} \int_{\infty}^{-\infty} f(x, y) e^{-i2\pi(xk_x + yk_y)} d_x d_y \qquad (1)$$

where scaling constants have been omitted, $i = \sqrt{-1}$ and ω is the angular frequency $\omega = 2\pi f$. Figure 3 (left) shows the $k_x - k_y$ domain of the time slice through the Vacuum field data set shown in Figure 2 and Figure 3 (right) shows the corresponding $k_x - k_y$ domain coherency attribute shown on Figure 2.

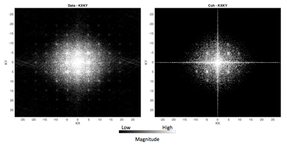

Figure 3: Left: $k_x k_y$ transfrom of the input data. Right: $k_x k_y$ transfrom of the coherence

Continuous Wavelet Transform : We will define the wavelet transform in a similar fashion as C. Liner (2010), applying the concept in the space domain. Thus:

$$f(a, b, \kappa, \nu) = (ab)^p \int_{\infty}^{-\infty} \int_{\infty}^{-\infty} f(x, y) \psi(\frac{x - \kappa}{a}) \psi(\frac{y - \nu}{b}) d_x d_y \qquad (2)$$

where $f(a, b, \kappa, \nu)$ refers to the transformed function, $f(x, y)$ is the original function in the space domain and ψ is the wavelet applied to the function."a"and "b"will be the scaling parameters, while "κ"and "ν"will be shifting values. The wavelet applied may or may not differ for each dimension, .

Filter Bank: A filter bank is a system that divides an input signal into a set of analysis signals, each of which correspond to a different region in the spectrum of the original signal (Cassidy and Smith, 2008). The design of the filter bank was very simple: cosine based wavelets were created with an argument that is modified depending on the region of the wavenumber domain that is being analyzed. The general form of such cosines will be:

$$FB2D(k_{cx}) = \left(cos \frac{k_{cx} \pi}{2} \right)^2 \qquad (3)$$

where $FB2D$ is the filter bank being applied and k_{cx} is the central wavenumber component analyzed.

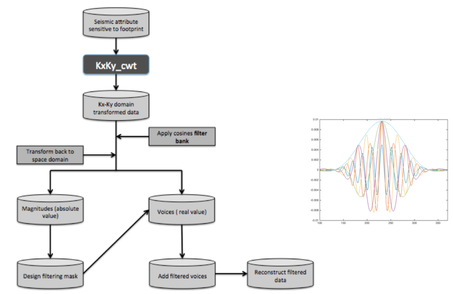

Figure 4: Left: $K_x K_y$ CWT code work flow. Right:The center trace in time from different filter banks.

Results

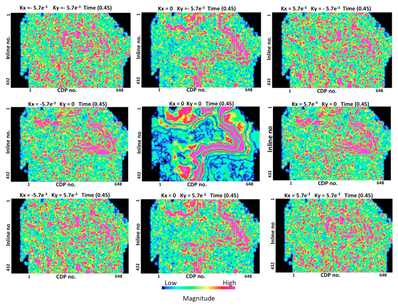

Figure 5: Time slice decomposed into different Magnitudes for different $k_x k_y$ components.

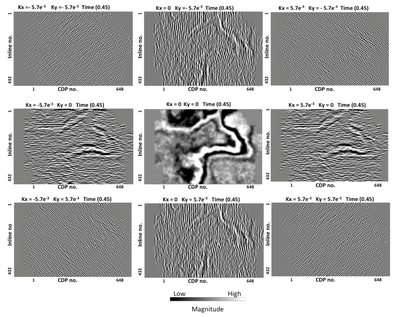

Figure 6: Time slice decomposed into different Voices for different $k_x k_y$ components with diagonal, vertical and horizontal trends

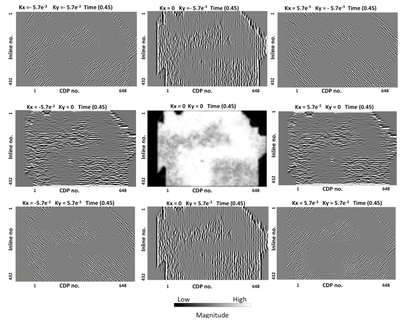

Figure 7: Coherence slice decomposed into different Voices for different $k_x k_y$ components with diagonal, vertical and horizontal trends.

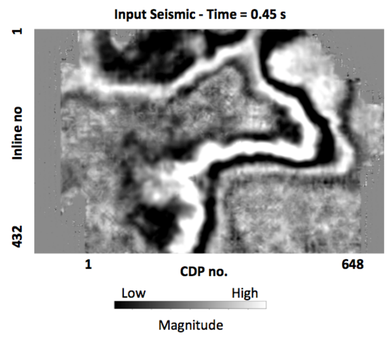

Figure 8: Filtered seismic data slice at 450 ms.

Conclusion and Future work

1. The choice of epsilon dictates the accuracy of the filtered result.
2. An appropriate number of components should be used to properly sample and filter the acquistion footprint.
3. Currently we are examining different approaches of applying the mask and preserving the singal better while suppressing the footprint noise.

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