On the broadband seismic data filtering using the Wavelet transform and the f-k filter

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Summary

The main objective of this work is to show how the discrete and the continuous wavelet transform perform for broadband seismic data filtering in petroleum exploration. Synthetic and actual broadband seismic data are filtered using the f-k and the wavelet transform methods; obtained results show the power of the f-k filter and the weakness of the wavelet transform in relation to its filtering of high frequency components.

Keywords: Broadband, filtering, seismic, wavelet transform, f-k filter.

Broadband seismic data filtering using the wavelet transform and the f-k filter

The wavelet transform is based on the decomposition of seismic data into a wavelet family extracted from a function called a Mother wavelet (Grossman and Morlet, 1984), and permits the time-frequency visualization of the seismic signal. The wavelet transform is used by the geophysics community to attenuate random noise (Ouadfeul et al, 2012; Ouadfeul et al, 2014) and to attenuate coherent noise such as ground roll (Prasad, 2006).

Ouadfeul et al (2011, 2014) have suggested to combine the discrete and the continuous wavelet transforms to attenuate random noise; the combined method shows the ability of the wavelet transform to improve the S/N ratio and its inability to preserve seismic amplitudes. Consequently, it cannot be used as a filter in AVO-AVA analysis for direct hydrocarbon accumulation prediction from seismic data.

Another important issue with the wavelet transform is related to its use in filtering broadband seismic data that contains generally higher frequency components compared to conventional seismic data. In this case we can easily demonstrate that the f-k filter is more suitable than the wavelet transform to pass from the time-space domain to the f-k domain, since the wavelet transform acts as a low pass filter that can attenuate potentially important high frequency seismic components. As a consequence the wavelet transform can decrease seismic resolution and limit its robustness. The f-k filter can be more useful in this case.

A weakness of the f-k filter can be seen in the case of dispersive ground roll attenuation, where the surface ground roll noise is not very coherent and its velocity field contains many components. The wavelet transform can better resolve and attenuate dispersive ground roll in the frequency domain versus the f-k filter.

Figure 1 shows an actual broadband seismic seismogram, while Figure 2 shows the seismogram filtered using the combination proposed by Ouadfeul and Aliouane (2013). The phase and frequency spectra calculated using the wavelet transform are shown in Figure 3, from which we can observe that frequencies above 100 Hz are attenuated by this process. As a result the wavelet transform has limited use as a tool to attenuate random noise from broadband seismic data.

Conclusion

For random noise attenuation in broadband seismic data we recommend the use of the f-k filter, as the wavelet transform method can attenuate high frequency components. The wavelet transform can also affect amplitude preservation. The f-k filter is not robust in dispersive ground role attenuation. In this case the wave atoms transform is recommended, since it has the ability to attenuate directional seismic components in the f-k domain.

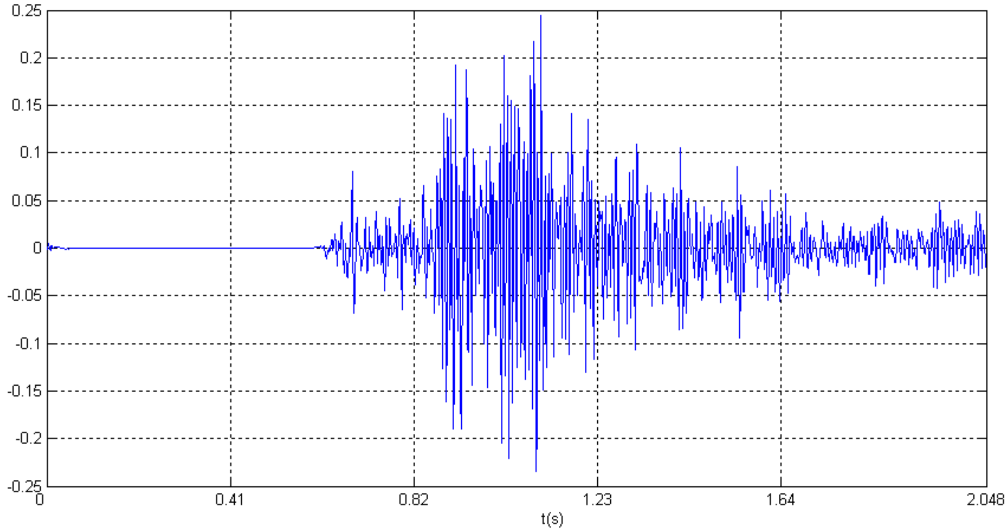

Figure 01: Seismic seismogram of a raw vertical seismic profile recorded in Algeria.

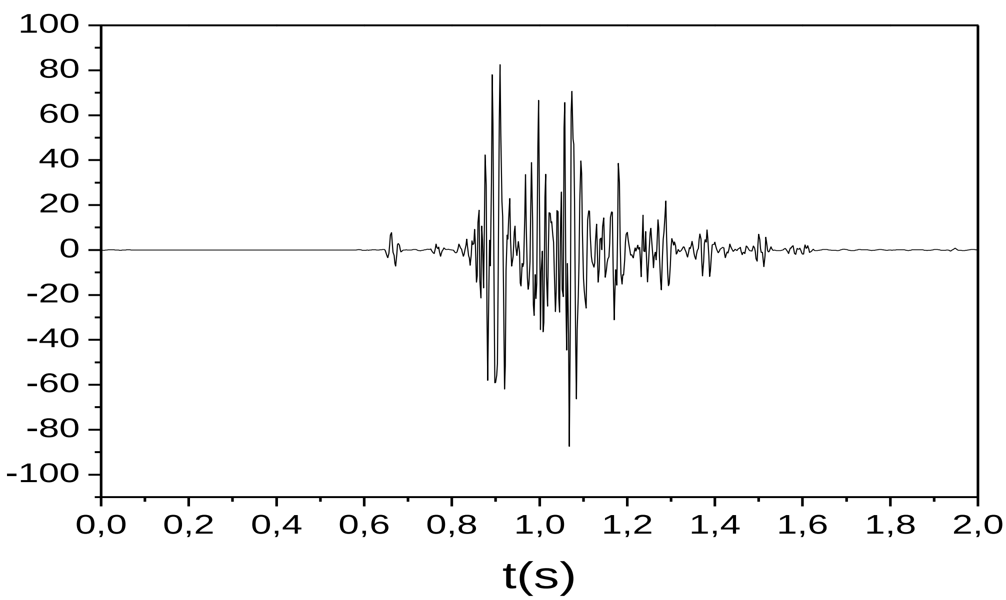

Figure 02: Denoised VSP seismogram using the continuous and the discrete wavelet transforms.

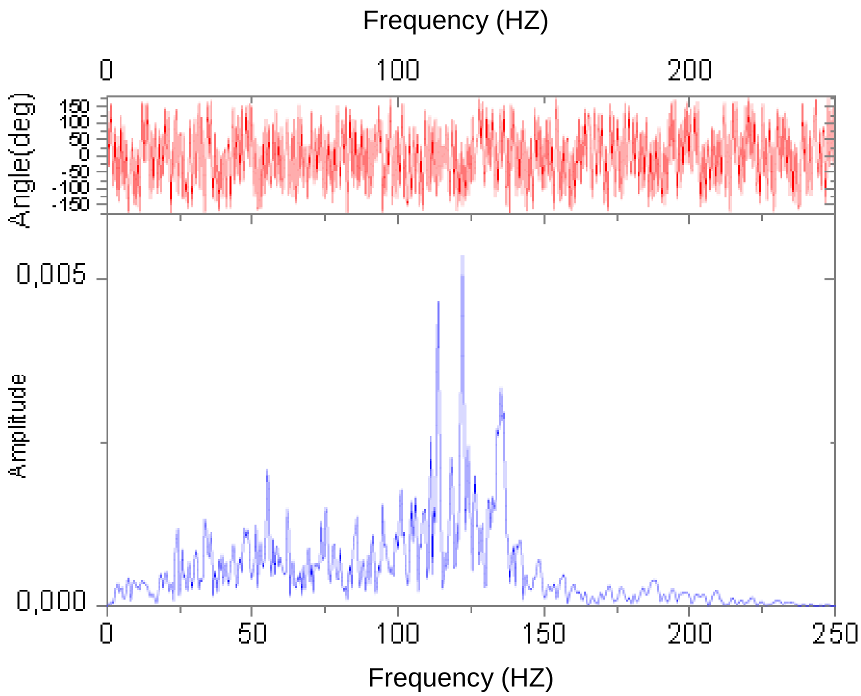

Figure 03: Spectral Analysis of the attenuated components by the combined wavelet transforms

References

Grossmann, A., & Morlet, J.,1984, Decomposition of Hardy functions into square integrable wavelets of constant shape. Siam Journal on Mathematical Analysis, 15(4), 723-736.

Ouadfeul, S., Aliouane, L., Eladj, S., 2011, Random Seismic Noise Attenuation Using the Wavelet Transform, 6th Congress of Balkan Geophysical Society, Extended abstract.

Ouadfeul, S., Aliouane, L., Hamoudi, M., Boudella, A. and Eladj, S., 2012, 1D Wavelet Transform and Geosciences, Wavelet Transforms and Their Recent Applications in Biology and Geoscience, Dr. Dumitru Baleanu (Ed.), ISBN: 978-953-51-0212-0, InTech.

Ouadfeul, S., Aliouane, L., 2014, Random seismic noise attenuation using the discrete and the continuous wavelet transorms, Arab Journal of Geosciences, Volume 7, Issue 7, pp 2531-2537.

Prasad, N. B. R., 2006, Attenuation of Ground Roll Using Wavelet Transform, 6th International Conference & Exposition on Petroleum Geophysics, Kolkata.