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Seismic resolution enhancement using complex wavelet transform

Alireza Goudarzi[1*] and Farhad Mollaei[2]

1- Assistant Professor, Faculty of Sciences and Modern Technologies, Graduate University of Advanced Technology, Kerman, Iran
2- M.Sc., Oil Engineering Group, Islamic Azad University, Lamerd Branch, Fars, Iran

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*** Corresponding author: a.goudarzi@kgut.ac.ir**

Keywords

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Extended Abstract

Summary

The resolution of seismic data decreases due to tuning effect, attenuation, and absorption and has always been one of the challenges for the interpreters. We can perform resolution enhancement in many ways, and in this regard, spiking deconvolution is the most critical approach. The ideal method to increase the resolution is to magnify or retrieve weak high frequency signals to provide a broad frequency spectrum, and therefore, substantially compressed signals. In this paper, a Hilbert-wavelet derived method has been investigated for this purpose. First, the input data using the wavelet transform (WT) are decomposed and enhanced by the Hilbert transform (HT) in the wavelet domain. The inverse WT yields compressed data based on current frequencies without any estimate and approximations. The Lack of significant distortions of recovered frequencies makes this process more distinctive than introduced methods. In this study, complex wavelet transform (CWT) and undecimated discrete wavelet transform (UDWT) are used. In fact, UDWT provides increased resolution, but on the opposite side, CWT presents impressive results. It deliveres fewer artifacts because of its time-frequency representations due to its unique combination of shift-invariant. This approach has been proposed and implemented to shot gathers after preliminary processing.

Introduction

We can characterize a seismic trace as a convolution of two unknown discrete time series: a source wavelet and reflectivity series. The reflectivity series can constitute the unknown geology. The objective of geophysical data processing is to get information of data to prepare interpretable results (Yilmaz, 2001). Researchers have stated various methods to enhance the resolution and frequency bandwidth, such as inversion-based and spectral methods. An additional approach for improving the resolution is deconvolution. Nevertheless, the efficiency of this method relies on many considerations, including noise and source type. Therefore, we cannot obtain the desired results perfectly (without any damage to the signal) (Yilmaz, 2001). Fourier-based methods cannot deal with non-stationary signals and suffer from side effects such as the frequency leakage. One method that has recently been implemented to geophysical data, is discrete WT to consider unstable properties of seismic data. The enhancement of the seismic bandwidth has been achieved based on several types of WTs (Rusu et al., 2011; Zhou, 2004; Rawat & Surinder, 2010; Ferner et al., 2012).

Methodology and Approaches

The CWT has been presented by Kingsbury (2001) and implemented by Goudarzi et al. (2014) for seismic noise attenuation. The wavelet in comparison with the Fourier analysis can handle wide ranges of signals. A deficiency of the DWT refers to signal representation at the discrete number of decomposition levels. Each level has twice the frequency content than the previous level. Pinar (1985) and Rao et al. (1982) determined fault parameters by applying the HT on gravity and magnetic data. In this paper, a Hilbert-wavelet derived method for this purpose has been examined. First, the input data using the wavelet transform (WT) are decomposed and enhanced by the HT in the wavelet domain. The inverse WT yields compressed data based on the current frequencies without any estimate and approximations.

Results and Conclusions

Seismic resolution enhancement is an essential step in geophysical data processing. It is implemented for the thin layer identification as a necessity for hydrocarbon exploration. A data-oriented approach has been proposed for improving the seismic resolution using DWT and HT. We have used this method on synthetic data and three real sections. The results have shown that UDWT and CWT improve the seismic data resolution. However, CWT results are better than UDWT results for this purpose. The advantage of CWT method compared to UDWT is prominent. CWT produces fewer artifacts compared to UDWT due to the process because the CWT is less sensitive to abrupt changes than other similar WTs. CWT has considerably lower computational cost than UDWT due to less redundancy that is important for the seismic exploration industry. The results of the real and synthetic examples illustrate that the proposed method is beneficial for resolution enhancement of post-stack seismic data. We suggest that the method could be applied to shotgather after further filtering. This approach compresses the signal, and consequently, precise velocity analysis yields to a more accurate stacked section.