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Power line noise attenuation in seismic data using spectral interpolation

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Keywords

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Extended Abstract

Summary

Due to high cost of data gathering and in order to increase the quality of the data, the most important challenge in seismic data de-noising is maximum attenuation of seismic noise with minimum signal leakage to achieve maximum signal-to-noise ratio. Power line or fixed-frequency harmonic noise in the frequency range of 50 to 60 Hz is one of the factors that contributes to decrease seismic signal quality, and also, reduces signal-to-noise ratio. This occurs through a frequency interference of a harmonic in the natural frequency range of the power lines (50 to 60 Hz) with the seismic signal frequencies.

Introduction

The most common methods for power line noise attenuation in seismic data processing is to use a notch filter, which is a narrow band-stop frequency filter that attenuates the frequency related to the harmonic noise from spectrum of noisy signal. It consists of one or more deep notches in the frequency response that can be used to attenuate the frequencies matched with the notches. Usually, the notch filter is designed using Z-transform. For this purpose, it is sufficient to put the zeros of the Z-transform on the unit circle in the Z plane at the angular frequency associated with the linear frequency of power line noise. For better performance of the notch filter, based on digital resonator theory, for every zero, a pole is considered near the position of zero with the same angular frequency of zero and an amplitude (r) smaller than one. The results obtained from applying the notch filter on synthetic and real seismic data showed that even at the largest value of r, the amplitude of neighboring frequencies of the harmonic noise frequency in the signal spectrum is also affected and leads to signal leakage.

Methodology and Approaches

An approach to attenuate power noise is spectral interpolation, which has previously been used in medicine to attenuate noise in the electromyogram and EEG and MEG signals. In this paper, the performance of this method is investigated on the removal of power line noise from synthetic and real seismic data. The spectral interpolation method for attenuating the power line noise involves the following steps:

- Transform seismic data from physical domain to frequency domain.
- Compute the amplitude spectrum.
- Compute and replace the amplitude of power line noise frequency by interpolation of neighboring amplitudes.
- Recover the denoised signal using modified amplitude spectrum and original phase spectrum.

In the proposed method, since interpolation is performed on the amplitude spectrum, the signal must be transformed using discrete Fourier transform to the frequency domain. The discrete Fourier transform length must be at least equal to the harmonic noise period to prevent leakage of noise to other frequencies. Furthermore, the frequency bandwidth for interpolation is also very effective. The larger frequency band for interpolation causes widespread distortions in the output signal.

Results and Conclusions

The proposed spectral interpolation method, unlike the notch filter method, is capable of attenuating the maximum harmonic noise with the least damage to the signal. Moreover, unlike the notch filter method, the spectral interpolation method does not zero the amplitude of harmonic noise frequency in the signal amplitude spectrum, but attempts to attenuate the part of the amplitude that is related to the harmonic noise and prevents that part of the amplitude related to the signal. Therefore, the spectral interpolation method can be used as an alternative to the notch filter for power line noise attenuation.