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Research Paper

Applicataion of ormsby wavelet for generation of synthetic seismic signals

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Abstract

Investigation of signals reflected from earth's surface and its crust helps in understanding its core structure. Wavelet transforms is one of the sophisticated tools for analyzing the seismic reflections. In the present work a synthetic seismic signal contaminated with noise is synthesized and analyzed using Ormsby wavelet[1]. The wavelet transform has efficiently extracted the spectra of the synthetic seismic signal as it smoothens the noise present in the data and upgrades the flag quality of the seismic data due to termers. Ormsby wavelet gives the most redefined spectrum of the input wave so it could be used for the analysis of the seismic reflections.

Keywords: *Convolution; Ormsby wavelet; Synthetic signal; Seismic signal*

1. Introduction

Automatic processing of seismic signal processing is a very challenging task for the detection and estimation of the impending earthquake's magnitude or any seismic hazard. Generally seismic signals recorded from a seismograph consist of different noises generated from different sources such as micro tremors, microseisms and artificial vibrations. This observed data has been traditionally processed by seismologists by different techniques. The data generated by the seismograph comprises of different phases and frequencies. It is required to pick up the original waves from the hidden noise.

Seismic reflection data is non-stationary in nature. The classical methods of detection of different frequencies could not be used. Wavelets transforms are the advanced version of signal processing techniques for the detection of signal frequencies of non-stationary in nature. Generally Stationary signal is a wave where peaks do not move spatially. The amplitude of the wave at a point in space and can vary in time, but it's phase remains constant. Stationary waves can be analyzed by Fourier transform methods. But These methods could not detect the transient characteristics of signals. Wavelet transform gives time and frequency spectrum of the signals localized by which the time of occurrences of the peaks can be analyzed.

A wavelet is defined as a wave like to and fro motion (oscillation) with certain amplitude which begins at zero increases and decreases ,again returns to zero. Wavelets consist of a function called the mother wavelet[2]. The mother wavelet is shifted in both time and frequency for analysis of the given input data. The convolution of the mother wavelet with the given input signal having various time shits and frequencies. This helps in the detection of both low and high frequency components present in the time series data. If the mother wavelet contains a phase component, then it is called as complex wavelets. These wavelets are helpful in extracting of phase information of the input signals.

Compared to Fourier transforms, wavelet transforms are more advantageous in performing discontinuous functions for either periodic or non periodic having constructive or destructive peaks [3]. Wavelet transform overcomes the drawbacks of Fourier transform, particularly for short time analysis of seismic signals. Commercially accessible softwares are used to produce engineered seismograms. This gives the geophysicist a choice of selecting up to four sorts of standardized wavelets namely, Ricker wavelet, Ormsby wavelet, Klauder wavelet and Butterworth wavelets[4]. Among which, Ormsby wavelets can estimate precisely the seisimogenity due to earth quakes.

Seismic signals are having transient behavior, which radiate natural/manmade noise in accordance with seismic sources, Location of source mechanisms and propagation medium structure through which they travel. Seismograph is a monitoring instrument which measures motion of ground's surface for the prediction of earthquakes and volcanic eruptions. An early warning system is needed to detect and observe the magnitude, so as to avoid the damage due to these natural calamities, the earthquakes[5].

2. Methodology

Ormsby wavelet is a wavelet whose frequency spectrum is of trapezoidal form. When such wavelet is given to a unit impulse filter it generates a signal having many side lobes. The wavelet is defined having four different frequency's f_1 to f_4. They are the lower-cut off frequency, the lower-pass frequency, the higher-pass frequency and the higher-cut off frequency's. This results in providing a good spectral resolution of the input signal which is similar to that of a band pass filter. Ormsby wavelet is a zero-phase wavelet containg a couple of side lobes rather than remaining wavelets which are of having plenty side lobes[6]. Ormsby wavelet is symmetrical about a vertical line through its central peak at time zero (Fig.1).

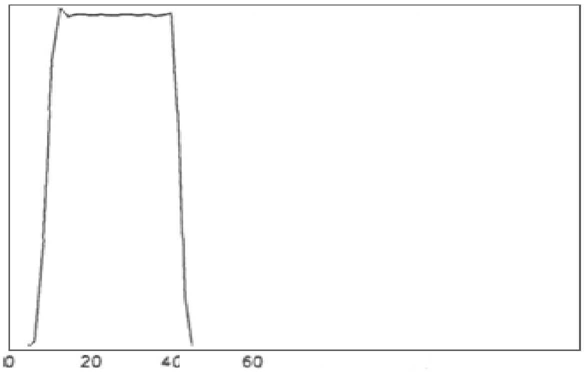

Fig. 1. Symmetrical Ormsby wavelet along vertical line.

Ormsby wavelet X(t) is the system's input signal, which is applied to an unit impulse function by which creation of Ormsby wavelet takes place as is shown in (Fig.2). A reflected wave H(t) and Ormsby wavelet X(t) are convoluted to obtain the synthetic sesimogram Y(t).The reflected wave relates to the geological section in which Noise is added further. The reflected signal will have a characteristic feature to distinguish the time-frequency space (Fig.3). The Ormsby wavelet will also become more colossal bluff for the slope of trapezoidal filter sides[7].

Convoluted signal Y(t)= X(t)*H(t).

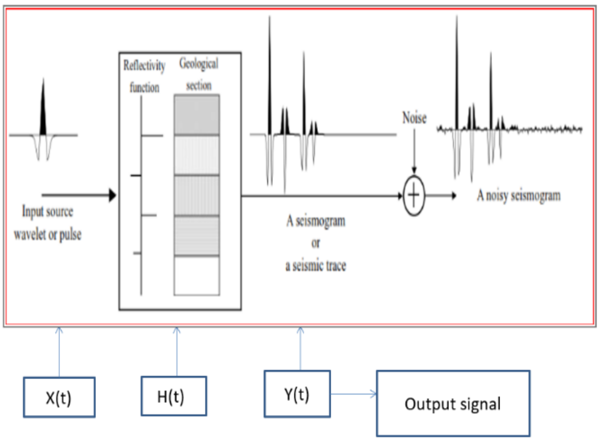

Fig. 2: Block diagram for Convoluting Synthetic Seismic data

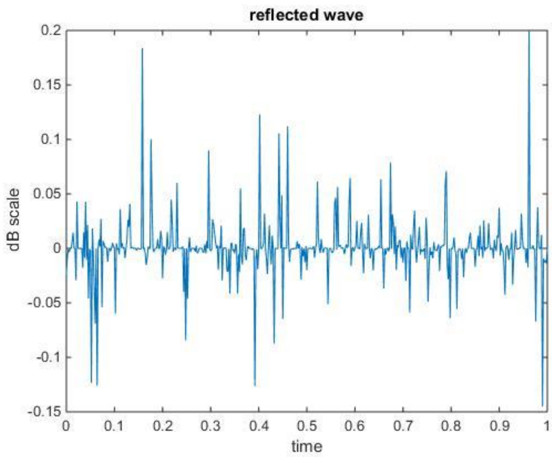

Fig. 3. Reflected Signal

In order to generate the shape of Ormsby wavelet, four frequencies are required. As specified in formula mentioned below(1). Let f1, f2, f3, f4 be the frequencies (Fig.4) .

$$Ormsby(t)=\left[\frac{(\Pi f_4)^2}{(\Pi f_4-\Pi f_3)}\sin\left(c^2(\Pi f_4 t)\right)-\frac{(\Pi f_3)^2}{(\Pi f_4-\Pi f_3)}\sin\left(c^2(\Pi f_3 t)\right)\right]-\left[\frac{(\Pi f_2)^2}{(\Pi f_2-\Pi f_1)}\sin\left(c^2(\Pi f_2 t)\right)-\frac{(\Pi f_1)^2}{(\Pi f_2-\Pi f_1)}\sin\left(c^2(\Pi f_1 t)\right)\right] \quad (1)$$

fl - the lower-cut frequency; f2- the lower-pass frequency;

f3-the higher-pass frequency; f4- the higher-cut frequency

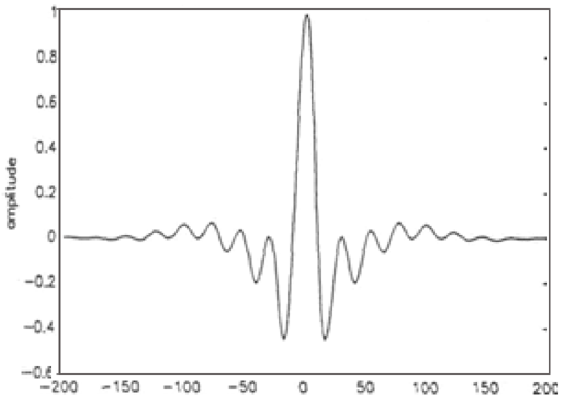

Fig. 4: The frequency spectrum of a Ormsby wavelet (fig ***2***) plainly demonstrates the significant similitudes between a Ormsby and an Klauder wavelet.

As there are many product resembles in 'c' and 'Fortran'. Yet 'Matlab' (MATRIX LABORATORY) is used because of its overcomeness of the above mentioned languages. The CREWES matlab is a substantial in gathering the geophysical schedules in which every module has been checked for consistency and exactness. More calculations are overhauled and exchanged to this crews matlab.

3. Result and discussion

Step-1: Ormsby wavelet is taken as an input signal and is represented as x(t)

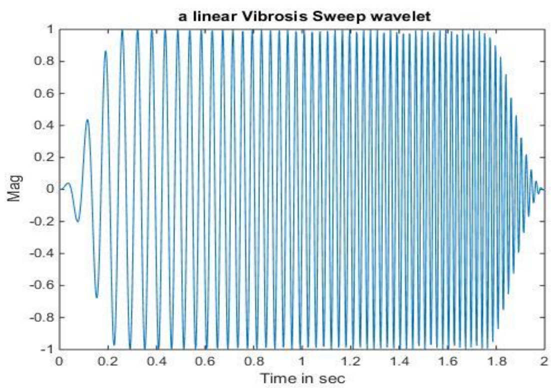

Fig. 5: Representation of a Ormsby wavelet

Step-2: Impulse signal h(t) is taken as an seismic signal(earthquake signal)
Step-3: Y(t) is the output of the which is obtained by convoluting input signal and the impulse signal

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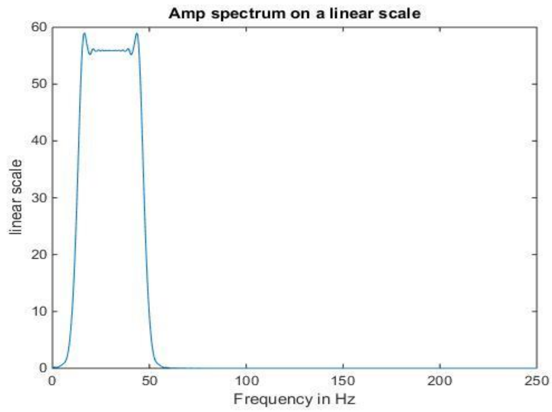

Fig. 6: Amplitude spectrum of a synthetic signal on a linear scale

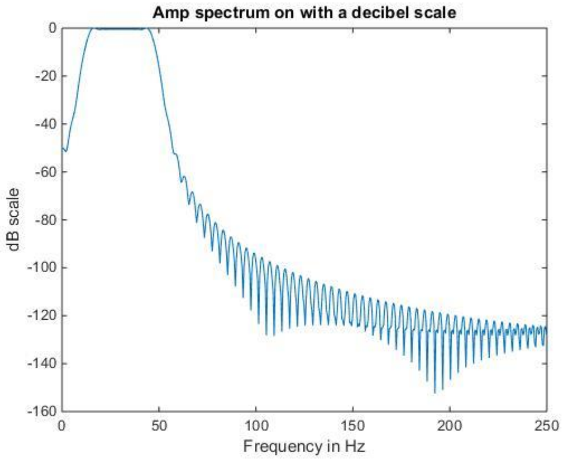

Fig. 7: Amplitude spectrum of a synthetic signal on a decibel scale

Step-4: Noise is added to the y(t) in order to obtain an noisy seismic signal.

Step-5: So on comparing the y(t) the output signal without noise and with noise we can easily understand about the disturbance caused to our original signal.

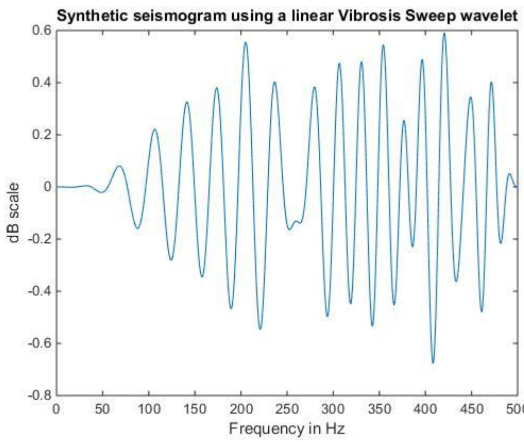

Fig. 8: Convoluted Ormsby wavelet with the synthetic signal to obtain the synthetic seismogram

4. Conclusion

Ormsby wavelet could extract the synthetic seismic signal hidden in noise. These methods are helpful in the exact detection of the time of occurrences of different frequencies in a seismograph signal. Real time application of these methods is helpful in accurate detection of time of occurrences of the P and S waves of an earthquake. These methods are also helpful in the analysis of earth’s crust.

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