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Research Paper

Application of minimum phase wavelet for generation of synthetic seismic signals

Yandamuri Surekha[1]*, Akety Sai Prathyusha[2], K. S Ramesh[3], S. Koteswara Rao[4]

[1]Student KLEF
[2]Student KLEF
[3]Professor KLEF
[4]Professor KLEF
**Email: surekhayandamuri96@gmail.com*

Abstract

Seismic signals are analyzed by using different wavelet transforms to evaluate the magnitude of the signal. Through experimentation, it is reported that surface wave magnitude is greater than equals to three, it would affect the environment. In this paper, an attempt is made to apply minimum phase wavelet technique to analyze the seismic signals through minimum phase wavelets using CREWES data.

Keywords: *Seismic Signals; Minimum Phase Wavelet ; Crewes Software..*

1. Introduction

On surveying many techniques, it is observed that seismic reflection is better than other techniques. This includes the information from receivers like geophones and hydrophones for land and marine respectively transmitting over a narrowband channel[1].
Seismic waves are categorized into two types that are Body Waves and Surface Waves. Body waves can travel into the earth whereas surface waves travel along the surface of the earth. Body waves are further classified into compressional and transverse waves[1]. Compressional is also known as P wave which is the fastest wave and transverse wave is known as S wave.
SOFTWARE USED
In this paper, CREWES Matlab is used. It has an extensive collection of geophysical data that has developed by accumulation. The software is part of CREWES library. In this, each module has been checked for the precision[2]. **Fig 1** shows a minimum phase wavelet whose inputs are temporal sample rate, dominant frequency, wavelength. **Fig 2** shows magnitude spectrum in a linear scale. **Fig 3** shows absolute value phase spectra.
In order to convert amplitude spectrum into decibels we have used *Ampdecibels*(*f*) = 20log(*Amp*(*f*)/max(*Amp*(*f*)))

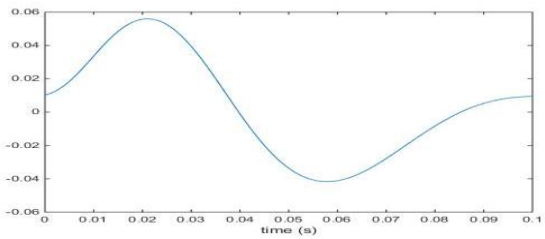


Fig. 1: Temporal sample rate

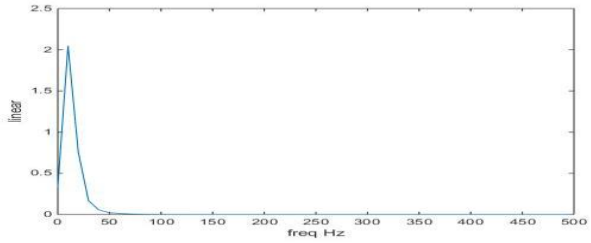


Fig. 2: Frequency sample vector

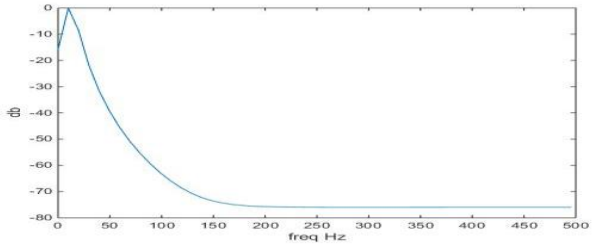


Fig. 3: Absolute value Phase spectra

Considering a causal system, minimum phase sequence x(n) and complex cepstrum c(n) such that c(n)=0 for n<0.
For a non-causal, the minimum phase sequence x(n) and complex cepstrum c(n) such that c(n)=0 for n>0.

A minimum phase sequence x(n) and its complex cepstrum c(n) can be written as[3]

$$x(n)=\begin{cases} e^{c^{\wedge}(0)}, & if \quad n=0 \\ \sum_{k=-\infty}^{\infty}\left(\frac{k}{n}\right)c^{\wedge}(k)x(n-k), & if \quad n\neq 0 \end{cases} \tag{1}$$

If x(n) is a finite minimum-phase sequence, then termed as [3]

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$$x(n)=\begin{cases} e^{c^{\wedge}(0)}, & if \quad n=0 \\ \sum_{k=0}^{n}\left(\frac{k}{n}\right)c^{\wedge}(k)x(n-k), & if \quad n>0 \end{cases} \tag{2}$$

2. Methodology

A wavelet has a decomposing factor which is an oscillated wave with zero mean, dissimilar to sinusoidal. Wavelets are different shapes and sizes. For example, Minimum phase wavelet. Wavelet is a key strength of wavelength analysis. There are two concepts of wavelets that are scaling and shifting.

Scaling has a factors of stretching and shrinking of a signal with time variance and it can be defined in the form of given eqution[4]

$$\varphi(t/s)*s > 0 \tag{3}$$

Where s = Scaling factor

t = Time

The reciprocal relationship between the time scale and frequency with a constant of proportionality. The other factor is wavelet shifting. Shifting the wavelet means delaying or advancing the onset of a wavelet along the signal. The result is expressed by using the expression given as

$$\varphi(t-k) \tag{4}$$

where k is centered point. Considering the wavelet transforms both in continuous wavelet transform , discrete wavelet transform. The Continuous Wavelet Transform analyze the time frequency domain. These wavelets does not have any negative feedback. For example such as morse, bump, analytic, morlet wavelets. The key application of cwt is analyzing time-frequency analysis and filtering of the localized frequency information [5].

On other hand Discrete Wavelet Transform is an ideal for noise free, which compresses the signals and images. This helps in constituting original signals and images. The main application of this analysis is noise free and compresses the signal and images [6]. Minimum phase is an important part of geographical surveys, a method to study particularly the seismic signals. A seismic signal with a wavelet is combined with a reflective function in a geographical section to provide a seismic trace [7].

The output of seismic trace is combined with the noise. To remove the noise we have used deconvolution method. We have observed that the frequency of the seismic signal having maximum amplitude. But in practically the amplitude should be very low at minimum phase[8].

Consider a synthetic pseudo-random reflectivity, it's generates a Gaussian random noise sequence and then raising each element in the sequence to a small integral power as shown in **fig 4**. This has the effect of making the sequence spikier [9]. To generate a minimum phase wavelet as a resultant using wavemin function for impulsive source as shown in **fig 5**. To generate a amplitude spectrum for impulsive sources use tntamp function. Then it is inverse Fourier transformed into a autocorrelation which is sustained into the Levinson recursion (levrec) which filters the minimum phase. The resultant from the levrec will be inverted to get final wavelet. Then the generated wavelet is forward Fourier transformed the real signed values as shown in **fig 6**. Later by applying the inverse Fourier transform generating the elements that are absolute to find out the magnitude shown in **fig 7**. The input reflectivity is convolved with the wavelet to generate a synthetic signal. Then utilizing the minimum norm method followed by normalization[10], it is observed that as the frequency increases shows that the seismic quality is having a zero mean and unit variance. Thus we get the noise free synthetic signal as shown in **fig 8**.

3. Results

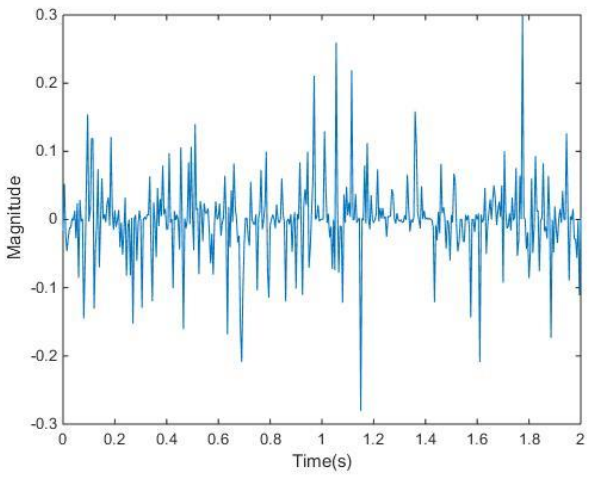


Fig. 4: Synthetic pseudo-random reflectivity of inputs record length, sample rate, amplitude, random number seed(m,n) to get reflected wave.

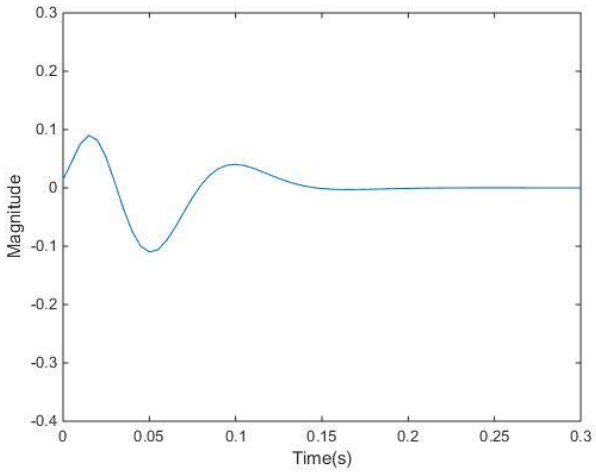


Fig. 5: Inputs of desired temporal sample rate, frequency in hertz, wavelength in seconds to get minimum phase wavelet.

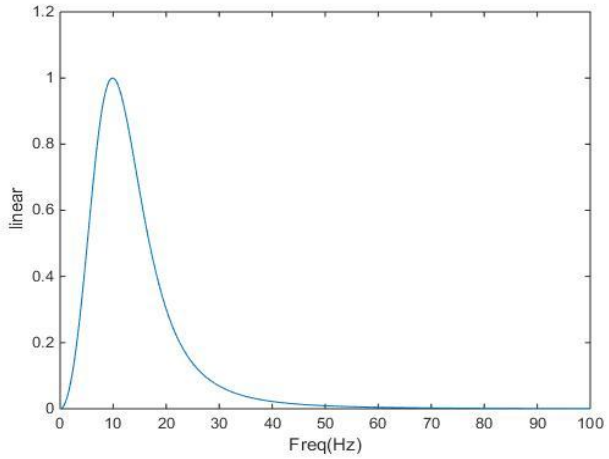


Fig. 6: Amplitude spectrum on a linear scale with inputs of minimum phase and time vector

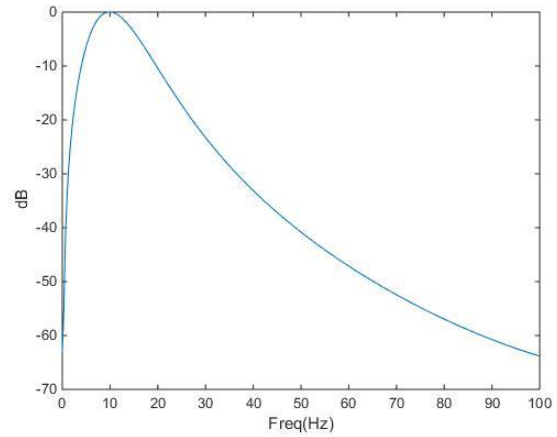


Fig . 7: Amplitude spectrum on a decibel scale which is absoluted the given elements to get magnitude.

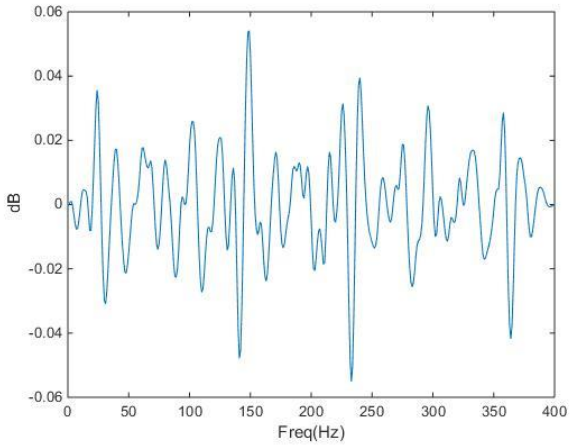


Fig. 8: convolving the synthetic signal with the wavelet to generate noise free synthetic seismogram.

4. Conclusion

The main part of the present research is that to analyze synthetic pseudo-random reflectivity with input parameters like length, sample rate, amplitude using FFT spectrum analysis in minimum phase wavelet. The result of this analysis is to generate a noise free synthetic signal by applying minimum phase wavelet.

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