Analysis Of Seismic Signals And Estimation Of Power Spectrum Using Blackman Turky Method

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Abstract: Seismic signals derived from the seismograms originated from the seismic waves due to the impending earthquake. The seismic waves thus emanated have elastic in nature and generate local variations of low acoustic energy associated with noise. It is very complex to analyze this seismic data with ambient noise and low energy. In this paper, an attempt is made to analyze the seismic data by applying a bandpass filter to minimize the noise. In addition to this, the power spectrum of these seismic signals has been analyzed by using Blackman Tukey methods to identify the dominant frequency components due to earthquakes.

Keywords: Stochastic Processes, Seismogram.

1 INTRODUCTION

1.1 Seismogram

Seismogram is a precise study of earthquake and understanding the nature of earthquakes. Earthquakes originated from different the sources namely tectonic plate movements, volcanic and oceanic eruptions under the earth. The seismic waves emanated are in elastic in nature [1]. The characteristic of seismic waves is elasticity. The main classifications of seismic data are categorized two waves, namely body waves and surface wave. The Body wave propagates into the innermost surface of the earth and surface wave gazing outermost surface. Whenever the earthquake happens, an abnormal energy is being released distributed from the epicenter.

1.2 Seismic Signal Processing

The energy thus dissipated is in the form of power spectrum distributed over a range of dominant frequency components. To identify the frequency component in the power spectrum, the seismic data is subjected to different statistical signal processing techniques. According to the literature, suppression of noise is focused by seismic signal processing [2]. TO differentiate the earthquake from noise, the change is observed between the new and mean data. Prior seismic of better performance is observed [3]. The seismic wave can be acquired from different stations of the world. From geophone the seismic response is obtained which converts from voltage to ground motion and to produce seismic waves. The seismic wave propagation during earthquake is categorized into three waves. Before the earthquake the prior signs have been observed. For prior signs of earthquake, satellite based gravity data is analyzed[4].

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- *ANALYSIS OF SEISMIC SIGNALS AND ESTIMATION OF POWER SPECTRUM USING BLACKMAN TURKY METHOD*

1.3 Blackman Tukey Method (Non-parametric)

The power spectrums of the signals are estimated using parametric and non-parametric methods. The power spectrum is estimated in parametric method by assuming a model. The power spectrum in the non-parametric method is estimated using statistical parameters. Auto-correlation sequence is estimated at the beginning for given data[5]. By using Blackman Tukey method which is non-parametric method, the power spectrum of seismic data is observed [6]. The decaying complexity of the signal is decomposed into simple components that requires the Spectral Density Estimation of each component subjected to spectral analysis resulting in reduction in statistical variability [7]. The amplitude square of the signal will give the power spectrum and it is a general technique used in signal processing [8]. The discrete Fourier transform is used to get the frequency spectrum [9]. By using FFT algorithm DFT can be calculated efficiently. To get the particular frequencies Band pass filter is used. The square components in the DFT is called periodogram. This cannot be applied to the signal which includes noise and the periodogram do not give processing gain [10][11]. By using Blackman Tukey method, it can be reduced which also known as Periodogram, which is smoothed by decreasing the statistical variability[12][13]. By considering the FFT window for auto correlation sequence, power spectrum is estimated in Blackman Tukey method. High power estimates are obtained by applying FFT. Blackman Tukey algorithm is applied to the particular frequency range which is obtained from band pass filter [14].

2 METHODOLOGY

To know how the statistical variability is reduced by periodogram smoothing, By using Fourier Transform of an autocorrelation sequence, the periodogram is calculated [15]. By considering the value of lag x=n-1, for a finite date of length n and variance R(x) will be higher for the values of x and nearer to n then the variance is

$$R(n-1) = \frac{1}{N} * Z(n-1) .* Z(0) \quad (1)$$

In Blackman Tukey, by implementing a window to the estimates unreliable, variance can be decreased. In Blackman Tukey, the spectral estimate is

$$P(e^{jw}) = \sum_{x=-m}^{m} R(x)W(x)e^{-xjw} \quad (2)$$

By using frequency convolution theorem, In frequency domain the spectral estimate can be rewritten as

$$P(e^{jw}) = \frac{1}{2\pi} * Pper(e^{jw}) * W(e^{jw})$$
$$= \frac{1}{2\pi} * \int_{-\pi}^{\pi} Pper(e^{jv}) * W\left(e^{j(w-v)}\right) dv \quad (3)$$

The bias and variance will be verified by examining the deployment of Black Tukey method. By presumed value the bias may be calculated

$$E\left(P(e^{jw})\right) = \frac{1}{2\pi} * Px(e^{jw}) * W(e^{jw}) \ (4)$$

By using Perseval's Theorem, the variance may be calculated as

$$variance\{P(e^{jw}) =\} Px^{2(e^{jw})i} * \frac{1}{n} * \sum_{x=-n}^{n} w^{2(k)} \quad (5)$$

3 SIMULATIONS AND RESULTS

Step 1: The analyzed data is taken from [3]. The source exists in the file is dynamite. It is in the depths of 80-100 ft. holes. Many traces are available , each trace consists of 1501 samples and 0.002 hertz of sampling frequency used for spectral analysis.

Step 2: To estimate the performance of algorithm, tonal signals are found, these are done before to the application of algorithm to signal.

Step 3: In figure 1, Due to the occurrence of earthquake the synthetic signal is recorded.

Step 4: In signal the power spectrum is observed. The implementation of algorithm is fine as it is showing in figure 2, the normalized frequencies at 0.2π and 0.4π.

Step 5: In the suppression of noise, the raw seismic signal is in figure 3.

Step 6: To eliminate any mean or bias, the raw signal is de-trended as shown in figure 4.

Step7: Spectral density is calculated when Blackman Tukey algorithm is implemented to the de-trended signal. 0.1π is normalized frequency and calculated further is shown in figure 5.

$$w = \frac{2\pi}{fs} f \ = 0.1 = \frac{2\pi}{500} f \ = 0.1\pi$$

$$Total\ frequency\ f = 0.1 * \frac{500}{2} = 25Hz$$

Step8: Frequency of band pass filter ranging 15Hz to 60Hz. Order 8 band pass filter and obtained filter frequency spectrum as shown in figure 6.

Step9: Seismic signals de-trended is convolved with the FIR BPF.

Step10: Frequency versus magnitude plot and filtered BPF signal as shown in Figure 9.

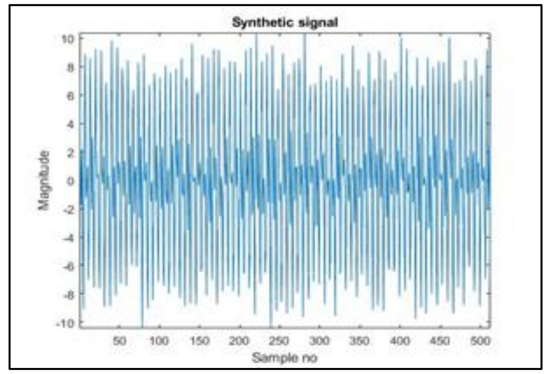

Figure 1.*Synthetic signal*

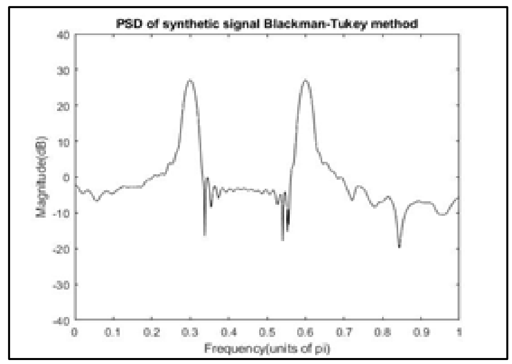

Figure 2*. Synthetic signal PSD*

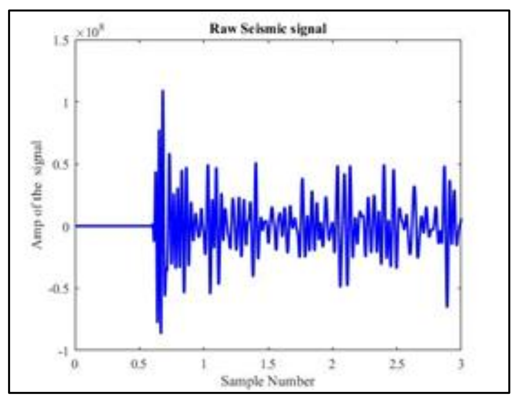

Figure 3*.Raw seismic signal (Raw)*

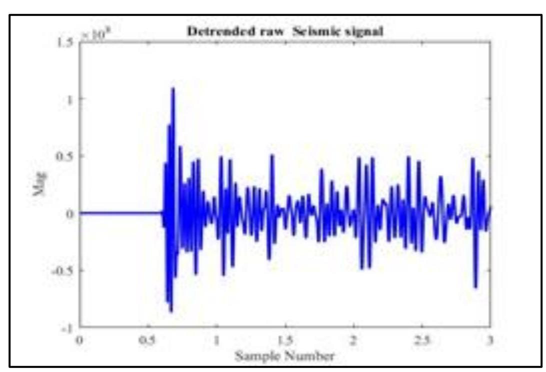

Figure 4*.seismic signal(Detrended)*

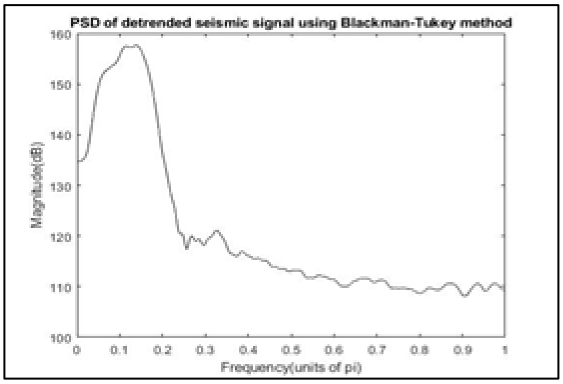

Figure 5*.Detrended Signal spectrum(PSD)*

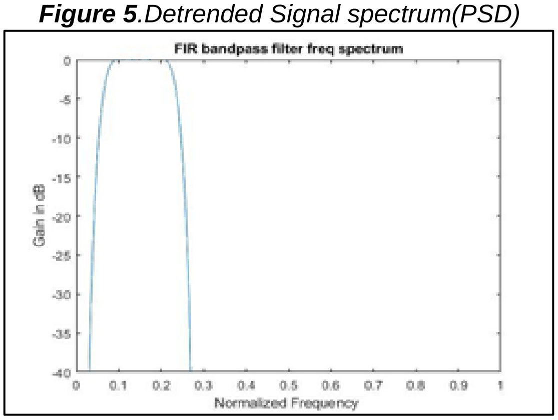

Figure 6.*Frequency Signal (Filtered)*

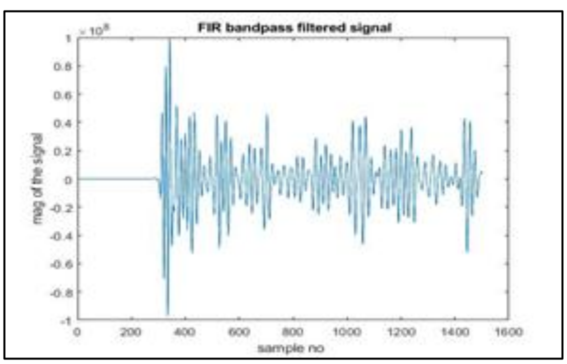

Figure 7.*band pass filtered.*

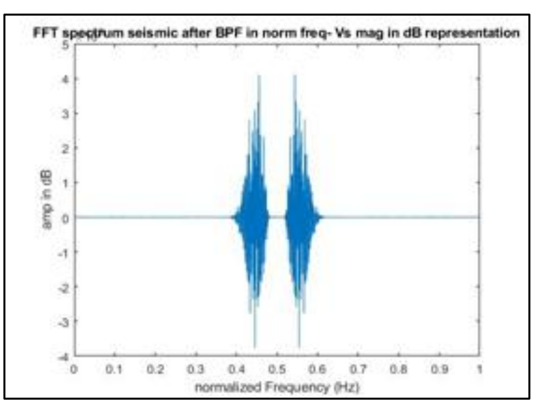

Figure 8.*Amplitude versus Signal(FIR) frequency.*

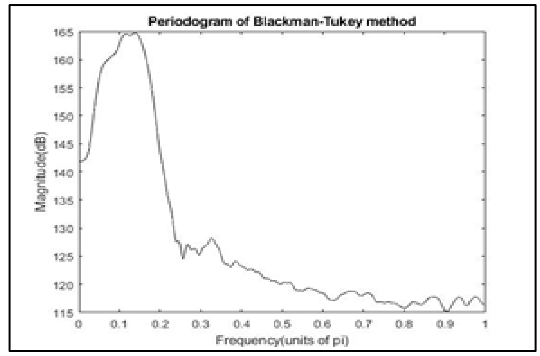

Figure 9*.BPF Filtered signal.*

4 CONCLUSION

It is observed that after analyzing the seismic signals, Blackman Tukey method could identify clearly the frequency components present in the power spectrum and are very correlated with the observed frequencies present during the earthquake. The band pass filter used here could remove the noise associated with the seismic data. By the Blackman Tukey algorithm, the statistical variability in the data is also reduced. This will be useful for the prediction of earthquakes in future.

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