The Application of Short Time Fourier Transform on Non-Stationary Seismic Signals

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ABSTRACT

Fourier transform plays a key role in interpolation of seismic sections. Fourier transform enables the interpreter to extract the frequency data which is needed for realizing various structures. Non-stationary signals behave extremely different though. When we are facing a non-stationary signal, finding the time-frequency map becomes a bit complicated. That is when the Short Time Fourier Transform (STFT) comes in handy. We will distinguish this different behavior of non-stationary signals through this text, and will examine STFT in practice.

Key words: Fourier Transform, STFT, Time-Frequency map, Matlab, Interpretation

INTRODUCTION

Time-frequency decomposition maps a 1D signal into a 2D signal of time and frequency, and describes how the spectral content of the signal changes with time. Time-frequency analysis has been used extensively in seismic data processing and interpretation, including attenuation measurement, direct hydro-carbon detection, and stratigraphic mapping. The widely used short-time Fourier transform (STFT) method produces a time-frequency spectrum by taking the Fourier transform of data windows, which leads to a tradeoff between temporal and spectral resolution.

The seismic traces are nothing but some signals. There are two types of signals; Stationary, whose frequencies is constant over time, and Non-Stationary, whose frequencies varies with time. For non-stationary signals, Fourier transform shows nothing applicable for interpretation, so for these types of signals we use short time Fourier transform (STFT) which is in fact a Fourier transform on a moving window over the signal. If we plot the time corresponding to center of the window on the trace versus the frequency calculated through the window, we will have the Time-Frequency Map of the trace. As it can be understood, for a single signal STFT will give us a 2D image for time versus frequency, hence for a set of signals we will have a cube of data in which one axis shows the number of signal or trace and the other two indicates time versus frequency.

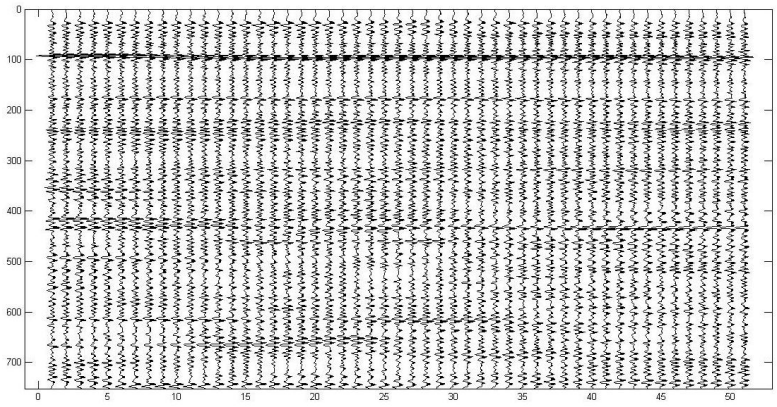

Figure 1. seismic section

Figure 1 shows a regular seismic section which includes 51 non-stationary traces each consisting of 751 time samples.
Getting a quick two dimensional Fourier transform using Matlab leads us to figure 2. As it can be seen, there is not that much of data we needed. So we now go for short time Fourier transform. We have a 2D section so it is expected to have a cube of data after applying STFT on the section in figure 1. The output cube will have two axes of 751 samples for time and frequency and one axis for the trace numbers.

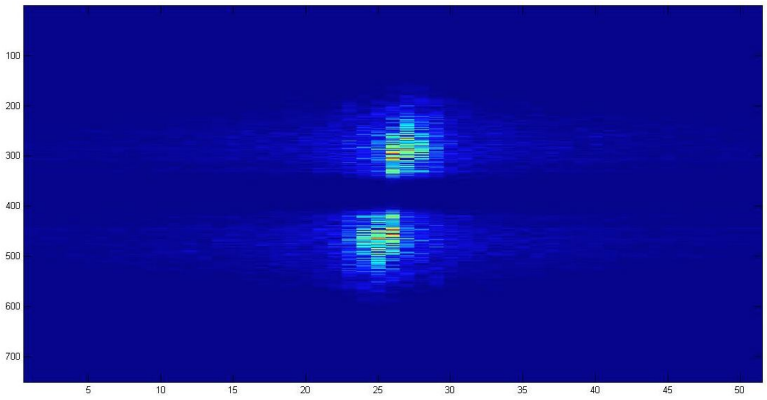

Figure 2. Two dimensional Fourier transform of the section in figure 1

To get the STFT, we need a window of the samples to isolate them for Fourier transform. Having the window constructed, we move it over each trace sample by sample, applying Fourier transform over the window; we will store the result for each window's movement in the cube. The result will be a cube of data which consists of time-frequency map of each trace.
Once the cube filled with the desired data, we can easily cut out various sections of the cube which include useful information could not been obtained from regular Fourier transform.
Figure 3 shows a single-frequency section for window length of 10 samples and frequency of 40Hz. The existence of 40Hz frequency through time over the section of figure 1 is barely visible in this single-frequency section.

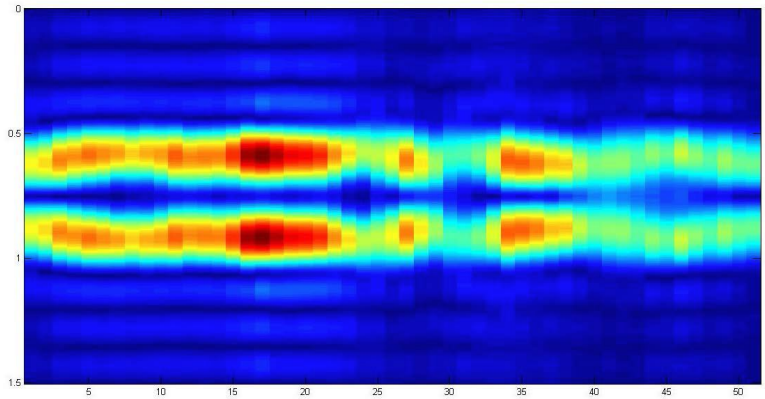

Figure 3. Single-Frequency map of the section in figure 1 for the frequency of 40Hz

CONCLUSION

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REFERENCE

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