N. Malini, 2022, 10:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Continuous Wavelet Transform for Seismic Wave Analysis

Asst. Prof. T. Jayasree, Ph. D Research Scholar N. Malini
Department of ECE,
Government College of Engineering,
Tirunelveli, Tamilnadu, India

Abstract- Wavelet transform is a signal processing technique that is used to analyze non-stationary seismic waves. The wavelet transform has been utilized as a strong signal processing tool in a variety of applications, including compression, time-frequency analysis, earthquake parameter calculation, and climate research, among others. In the study of time-frequency information in non-stationary signals, the continuous wavelet transform (CWT) has played an important role. As a result, we may describe the vulnerability of seismically active regions and local topological characteristics utilizing wavelet techniques.

Keywords- Wavelet analysis, Continuous wavelet Transform (CWT), Ground motion, 2015 Gorkha earthquake, Kathmandu Valley.

I. INTRODUCTION

In many concerns in seismology, the physical of digital signal processing in the waveform is quite important. The waveform is a non-linear statistical seismic signal generated by a sensor seismic network and extracted.

The use of wavelet analysis to classify seismic signals has been the subject of extensive research in digital signal processing. The wavelet transform is a technique for enhancing the better of a signal that is now not only efficient, accurate, but also effective [1], [2].

The prior work used band type seismic community versions to compute waveform categorization utilizing Continuous Wavelet Transform (CWT). The CWT is a particularly effective method for assessing the time-frequency component of facts whose spectral delight fluctuates with time [3], [4].

II. METHODOLOGY

The CWT (Continuous Wavelet Transform) gives extensive temporal and scale information about a signal. To solve difficulties like data availability and quality, database error spots, and gaps, the CWT

$$w(a,b) = \int f(t)\phi*\left(\frac{t-b}{a}\right)dt$$

Where 'a' and 'b' are dilation and translation parameters, respectively, and φ∗ denotes the complex conjugate [5], [6].

The wavelet coefficients are represented by the W (a, b) function. This wavelet transform was used because it is good for concurrently localizing time and frequency. With this, we may examine the signal's low and high frequency properties, as well as its time period.

III. RESULT AND DISCUSSION

The use of wavelet-based analysis clearly improves our comprehension of the events. It connects energy bursts to the arrival of seismic waves. The focus of this investigation is mostly on CWT.

1. Ground Motion Analysis:

It is vital to increase our understanding of ground motion induced by earthquakes in order to develop seismic hazard assessment and mitigation. The investigation of the severe earthquake's significant ground motion characteristics after the aftershock occurrences observed on the location TVU (Central Department of Geology, Tribhuvan University), THM(University Grants Commission office, Bhaktapur)`[7], [8] .

2. Data Set:

The ground acceleration data recorded at a sample rate of 100 HZ during an aftershock event on April 25, 2015 was used in this article. The horizontal and vertical axes, respectively, have a time scale in seconds and ground acceleration in cm/s2. In the Kathmandu valley, there is a lot of ground motion [9], [10].

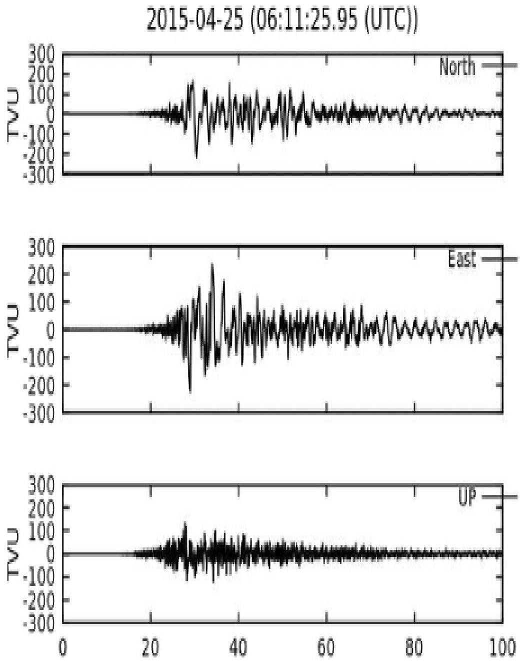


Fig 1. Ground acceleration waveform recorded at station TVU. The x-axis and y-axis represents time scale in seconds and ground acceleration in cm/s^2.

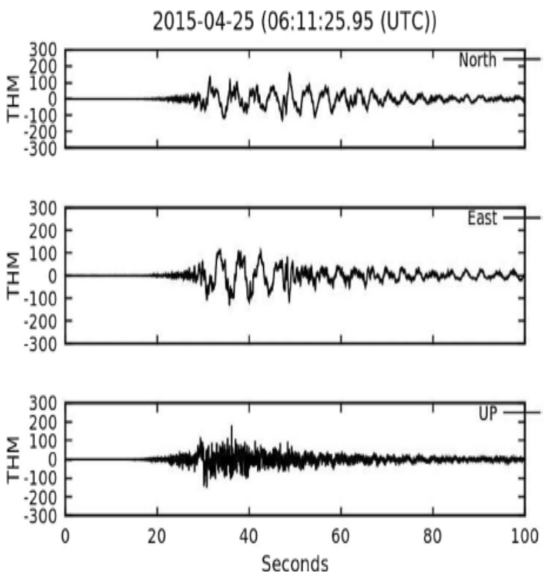
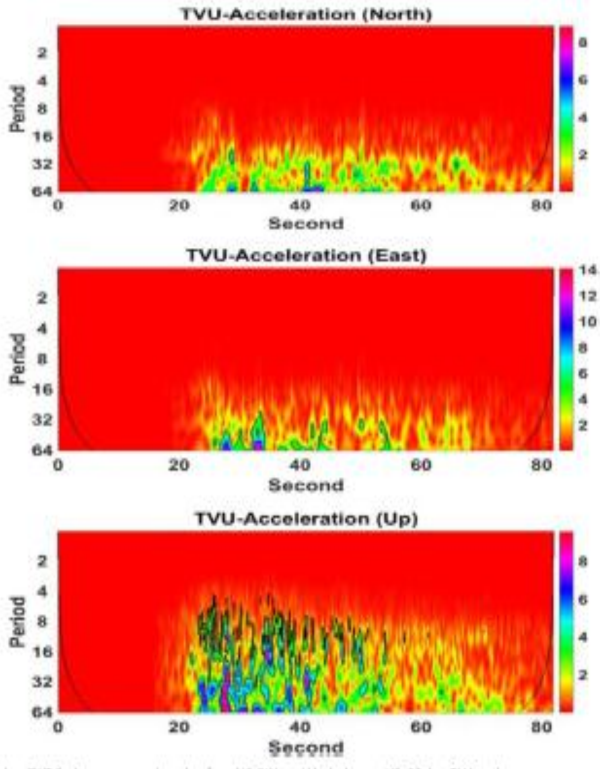
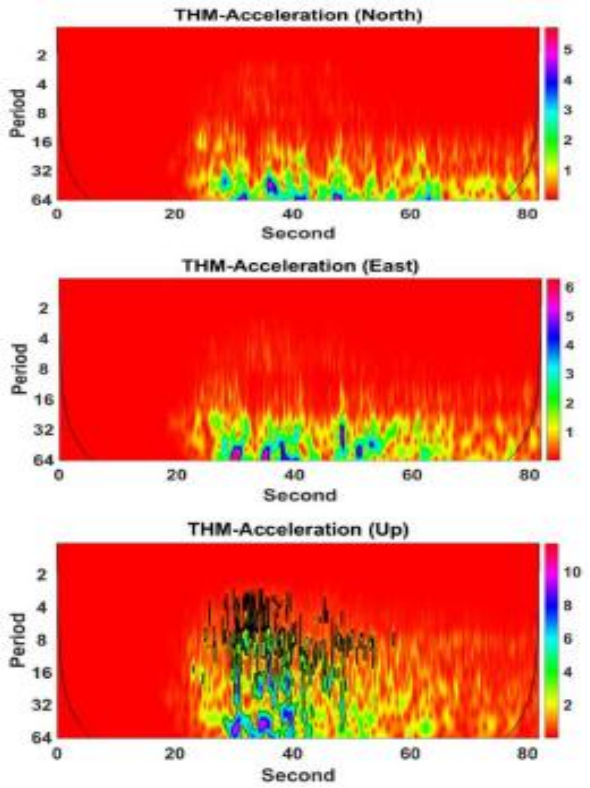


Fig 2. Ground acceleration waveform recorded at station THM.

3. CWT Analysis:



(a)



(b)

Fig 3. Two Dimension CWT-Scalogram ground motion from NS, EW, and Vertical record (0–80 s) at TNU, THM station.

The horizontal axis in these graphs represents the time scale, while the vertical axis represents the period. These diagrams allow you to display signal energy distributions in both frequency and time, as well as study some specific features. The first component is to equate amplitude amplification by signal discontinuities, and the second is to notice abrupt shifts.

At 06:11:25.95 UTC, the aftershock begins (25 April 2015). During the earthquake, we can see long-duration horizontal motion with a high frequency in Fig. 3. For NS and EW ground motion, there is a pink, blue, and green band in the period range of 64–32 (0.015–0.031 Hz) seconds, whereas for vertical motion, those bands are in the period range of 64–8 (0.015–0.125 Hz) seconds. The greatest frequency spectrum of ground motion was detected in the horizontal scalogram (Fig.3, 4).

At the comparison scales at every interval of each component, the less intense areas may be noticed. This shows that the earthquake's periodicity is continually transmitting. We can also notice that the zones with lower frequency appear more frequently, whereas the zones with higher periodicity appear less frequently. This is completely in line with the frequency periodicity inverse relationship, i.e., high frequency components with low periodicity and high intensity are found to be in the period range 64–32 s (0.015–0.031 Hz).

As a result, any structure with natural frequencies falling within or close to this frequency spectrum has a significant likelihood of experiencing resonance and being destroyed. As a result, we discovered that CWT is a useful instrument for studying the nature of seismic waves.

IV. CONCLUSION

This study summarizes the benefits of using wavelet methods in seismic applications. The major goal of employing these approaches is to reveal the original signal's hidden properties as well as to improve its analysis.

Based on the three-dimensional acceleration structure, it is concluded that the wavelet transform is a powerful analytical tool for recognizing the characteristics of input motion in both time and frequency and understanding the variables associated with long-period response of seismic sensitive sites. This is in charge of the structures' dynamic behavior and protection. Finally, it is determined that topographical factors of the Kathmandu valley may contribute to substantial destruction.

REFERENCE

[1] M. Dct, “Wavelet Theory and Application,” Wavelet Theory Appl., 1993, doi: 10.1007/978-1-4615-3260-6.

[2] M. K. A. & R. B. N. Prabhu, “Wavelet Based Feature Extraction Techniques of Hyperspectral Data | SpringerLink,” Springer, 2016.

[3] Adhikari B, Khatiwada R, Chapagain NP (2017) Analysis of geomagnetic stormsusing wavelet trans-forms. J Nepal Phys Soc 4(1):119–124

[4] Salajegheh E, Heidari A (2002) Dynamic analysis of structures against earthquake by combined wavelet transform and fast Fourier transform. Asian J CivEng 3:75–87

[5] Mugnier JL, Huyghe P, Gajurel AP, Upreti BN, Jouanne F (2011) Seismites in the Kathmandu basin and seismic hazard in central Himalaya. Tectonophysics 509(1):33–49

[6] K. Gurley and A. Kareem, “Applications of wavelet transforms in earthquake, wind and ocean engineering,” Eng. Struct., vol. 21, no. 2, pp. 149–167, 1999, doi: 10.1016/S0141-0296(97)00139-9.

[7] C. Xia and C. Liu, “Identification and representation of multi-pulse near-fault strong ground motion using adaptive wavelet transform,” Appl. Sci., vol. 9, no. 2, 2019, doi: 10.3390/app9020259.

[8] A. R. A. and M. S. HelbertSirait, Kerista Sebayang, Syahrul Humaidi, Timbangen Sembiring, Kerista Tarigan, Kurnia Sembiring, Teguh Rahayu, “Time Frequency Signal Classification Using Continuous Wavelet Transformation – IOP science,” IOP Conference Series: Materials Science and Engineering, 2020.

[9] B. Grecu, C. Neagoe, and D. Tataru, “Seismic noise characteristics at the Romanian broadband seismic network,” J. Earthq. Eng., vol. 16, no. 5, pp. 644–661, 2012, doi: 10.1080/1363246 9.2011.642931.

[10] T. K.-C. And A. Kareem, “Efficacy of Hilbert and Wavelet Transforms for Time-Frequency Analysis | Journal of Engineering Mechanics | Vol 132, No 10,” asce, 2006.