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Machine Learning for Waveform Spectral Analysis on Nuclear Explosion Signal and Performance of Broadband Vertical Component

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Abstract. Machine learning of nuclear explosion signal waveform is core component to realize the characteristics of signal. The processing of waveform explosion signal is broadly used for analysis of real time explosion signal. The numerous wavelet filters are developed by spectral synthesis using machine learning python to realize the signal characteristics. Our paper aims to generate the performance of nuclear explosion signal and processing the waveform from seismic sensor by using Continuous Wavelet Transform (CWT). CWT is also clearly to identify of spectral amplitudes and frequency-energy from component of signal seismic performed by Broadband Network in Indonesia. Finally, by machine learning python allows good time resolution for identified and performed of seismic signal from broadband which deployed in Indonesia.

1. Introduction
Machine learning is the process techniques attempt to leverage the concept and principle of “learning” the formulas associated with different types of nuclear signal characteristics. In general, machine learning is a fantastic way for evaluating time series. In the broadband network, most of the data collected are a time series. Each waveform channel of time series data is identified by a 3-character channel code like BH* (BHN, BHE, and BHZ). In this case, we analyzed the channel of BH* with Broadband Vertical Component (BHZ). The signal of a nuclear explosion was differentiated from the base natural source of either earthquake. We analyzing explosion waveforms from a broadband network of the seismic station which deployed in Indonesia. The broadband network had been produced the type of the standard for exchange of earthquake data (SEED). The Standard for the Exchange of Earthquake Data (SEED) was developed and designed for digital signal research community[1]. Digital methods are not only increased data quality but also created new challenges.
We select the BATI station, which a part of CTBTO’s network station in Indonesia and analyze the performance and characteristics of nuclear explosion signal on North Korea that occurred on September 03, 2017. In this paper aims to generate the performance of nuclear explosion signal and processing the waveform for analyzing the characteristic of the waveform of signal seismic as a nuclear explosion by using machine learning python on morlet and using the power spectral density. Analyze seismic noise for the broadband seismic station had been done by using power spectral density [2-3], the other researcher tries to identify the performance of seismic station[4-5]. Machine learning python (MLPy) in this case to perform a morlet wavelet transform by analysis of waveform signal from broadband seismic data recorded on September 03, 2017 with Magnitude 6.3 and Depth 1.0 Km. By using machine learning python (Mlpy) on wavelet transform allows good time resolution for low frequencies of nuclear explosion characteristic.

2. Data and Method
2.1 Data
The waveform data were employed from BMKG-IA real-time seismic monitoring network at the Indonesia Tsunami Early Warning System (Ina-TEWS). We use the nuclear test on September 03, 2017 from North Korea as a research area, the location of each of CTBTO’s broadband stations is shown in figure 1 and table 1. We take the BMKG-IA broadband station seismic by using the available data on September 03, 2017. We used python to provide routines for the handling of seismic data. It provides read/write support for the most relevant waveform data formats in use the data center and observatories, its support the standard metadata exchange format of Dataless SEED (MSEED), and it comes with clients to interact with the most important data center at BMKG Network in figure 1.

![Figure 1. Distribution of CTBTO’s Broadband Network Seismic in Indonesia](image)

2.2 Method
In general, we generated the Mini-SEED data to SAC (seismic analysis Component) by python for 3 Component in Figure 2, Broadband Horizontal Component (BHE), Broadband Vertical Component (BHZ) and Broadband (BHE). We only analyze the Broadband Vertical Component (BHZ) on the waveform nuclear explosion recorded. The wavelet analysis discussed in this paper employed the application of the continuous wavelet transform (CWT) using the Morlet wavelet[6-8] and power
spectral density. This appeared effective and operative at identifying features in seismic data. We used the machine learning python (MLPy) by wavelet to processing the waveform of signal seismic [9-10].

Figure 2. BATI waveform with 3 Component (BHE, BHN, BHZ)

3. Result and Discussions
The results of the power spectral density of the time series on CTBTO’s broadband for one week in figure 3 indicated the good performance where the spectral waveform between New High / New Low Noise Model.

Figure 3. Power Spectral Density for CTBTO’s Station on BATI Sensor

The power spectral density of BATI between -160 dB until -90 db. There are small gaps for each CTBTO’s Station which indicated in red at the period on September 05-06, 2017.
In the machine learning python on morlet wavelet, we analyze all CTBTO’s broadband station to show the frequency-energy and looking at the characteristic of nuclear test waveform. From six CTBTO’s sensor, we got BATI station clearly recorded the nuclear explosion waveform.

Figure 4. BATI waveform by Machine learning package in python using morlet.

The waveform spectrum in figure 4 indicate the S-component is not clearly on BATI broadband network and using Machine learning python on morlet wavelet, show the P–component is clearly. The condition support the period of the waveform is available to analysis the nuclear signal explosion by continuous wavelet transform. The continuous wavelet transform showed the bluish color represented low energy and yellowish colors represented high energy.

Figure 5. BATI waveform of Broadband Vertical Component

The BATI waveform of broadband vertical component (BHZ) in figure 5 was generated from Mini SEED (MSEED) in Figure 4, it’s mean that the spectrum accumulated of mini seed. The spectrum
showed clearly on the spectrum amplitude of the signal and the phase of P is clearly. The representative of the nuclear signal explosion only shows the spectrum of the broadband component vertical (BHZ).

4. Conclusions
Based on the results obtained in the study, it was concluded that the nuclear explosion signal had been generated and using machine learning analysis of waveforms explosion signal obtained a useful way of observing the arraying spectral (time-frequency) components of a nuclear explosion broadband wavelet on wavelet method. CWT is possible to clearly and simultaneously of amplitudes and processing frequency-energy from the signal seismic component.

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