Application of Singular Spectrum Analysis to S Wave Picking

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The picking of the S waves is required for various seismological scenes such as hypocenter location, waveform inversion, and so on. Although S waves are prone to contamination by other phases, accurate and objective detection of S waves is important because that strongly affects the quality of the aforementioned analyses. In this study, the author applied Singular Spectral Analysis (SSA) for strong motion records to test the applicability of SSA for S wave picking.

SSA is one of the nonlinear signal processing techniques categorized into subspace method and has been used in various fields including geophysics. SSA is a nonparametric method, and the basis changes adaptively according to data. Therefore, non-stationary time series data can be analyzed accurately. Furthermore, the SSA performs dimensional compression by deleting the dimension related to the noise space and can realize robust analysis even for noisy data. Such a feature of SSA seems to be desirable for S wave picking.

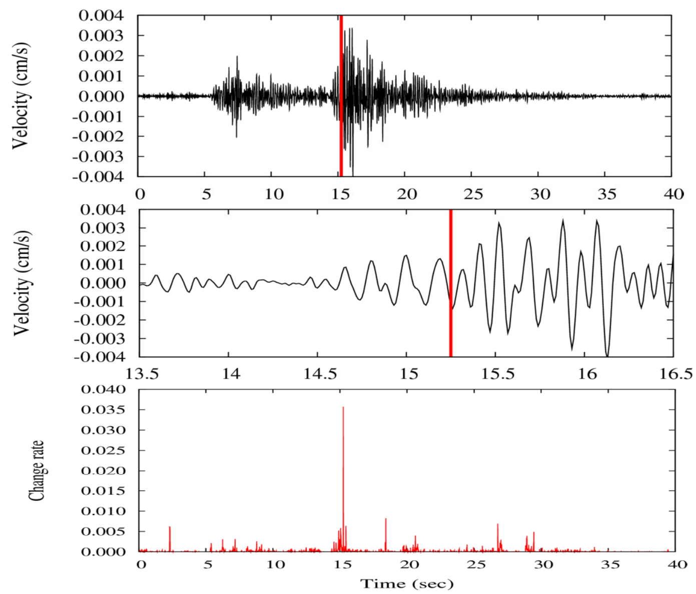

Figure 1. The upper figure: SH component of observed velocity waveform. The middle figure: Enlarged view of S wave arrival portion in the waveform. The lower figure: The degree of change in the waveform calculated by SSA. The red line of each figure represents the S wave arrival.

We applied SSA to the near field strong motion records of aftershock of the 2016 Kumamoto earthquakes recorded at K-NET and KiK-net stations. Strong motion records were integrated into velocity records and they were converted to the LQT coordinate system based on the direction of the P wave arrival to emphasize the SH component. S waves were picked by examing the degree of the change of the waveforms. The length of time windows and stack number in SSA were determined by trial and error. Spectral filtering was done adaptively at each time based on the contribution ratio of each spectrum.

An example of the S wave detection by SSA is depicted in Figure 1. The red line of each figure shows the S wave arrival detected by SSA. In this figure, we can see that SSA successfully detected the S wave arrival by tracking the change of the dominant frequency while the amplitude of the waveform starts increasing earlier than the S wave arrival due to the arrival of the wave other than direct S wave.

In the presentation, the results of S wave picking by SSA and the influence of the time window length and the number of stacking on results will be shown.