Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

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To enhance the reliability of seismic hazard assessment, it is important to improve the accuracy of predicting broadband ground motion. For predicting broadband ground motion, a hybrid method is often used. The hybrid method synthesizes broadband ground motion by summing up long-period and short-period ground motion calculated separately. The long-period ground motion is calculated by a theoretical method such as the finite difference method which can consider the effect of the three-dimensional velocity structure. The short-period ground motion is calculated by empirical or semi-empirical methods such as statistical Green's function method can consider the effect of random heterogeneity of seismic source and propagation path. These methods, however, use different velocity structure models, it is known that problems such as the shift of travel time, discontinuity of spectral amplitude between the period range.

For this problem, Iwaki and Fujiwara (2013) proposed a method of synthesizing broadband ground-motion waveform based on the relationship of ground-motion waveform between long-period and short-period extracted from observation data. We considered this problem of extracting the relationship between long-period and short-period ground motions as a problem of upsampling in artificial intelligence and have studied this problem using the coupling learning method (Nagata et al., 2016) which is one of machine learning methods (Maeda et al., 2018). To construct a prediction model of a short-period ground-motion waveform from long-period ground-motion waveform based on artificial intelligence, we can utilize a vast amount of strong ground motion data recorded by K-NET and KiK-net.

The performance of the prediction model is evaluated based on the similarity of observed and predicted broadband ground motion. In the previous study, we evaluated the similarity based on the time series data of the broadband waveform. However, in this study, we used an envelope shape of waveforms for narrowband of 0.5-1.0 Hz, 1-2 Hz, 2-4 Hz, 4-8 Hz, 8-16 Hz, and a Fourier amplitude spectrum for evaluating similarity. The data sets used for learning and testing of artificial intelligence were (1) records of a single observation site, (2) records of multiple observation sites with similar ground conditions, (3) records of multiple observation sites due to earthquakes of the similar magnitude, (4) records of multiple observation sites due to earthquake occurring same region, and (5) a whole records from (1) to (4). We found a tendency that the prediction performance is somewhat higher in the case (1). Qualitatively, it is expected that the prediction performance in the case (1) that can take into consideration the site-specific characteristic of ground motion will be significantly higher and the result of this study suggests that there is room for improvement in the similarity evaluation.

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