Denoising Ambient Seismic Field Correlation Functions with Deep Autoencoders

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In the last decade, seismic interferometry has become an established technique for monitoring the temporal changes of the Earth’s physical properties. This technique relies on measuring time shifts of seismic waves present in Green’s functions, which are generally approximated by cross-correlating 1-h long ambient seismic field records at two stations. To increase the accuracy of the phase information of hourly cross-correlation functions, pre-processing is generally applied to the recorded ambient seismic field, such as 1-bit normalization and/or pre-whitening. Despite this, hourly cross correlation functions often need to be stacked over a few hours/days to increase their signal-to-noise ratio and measure reliable phase shifts. We introduce a new technique for improving the time resolution of seismic monitoring, which denoises cross-correlation functions using deep autoencoders. Autoencoders are composed of an encoding function, which computes a compressed representation of the input data, and a decoding function which reconstructs a simplified representation of the input data. Both the encoder and decoder parts are composed of a stack of densely-connected neural network layers. Such an algorithm can be trained to denoise corrupted versions of their inputs, which in our case are correlation functions with low signal-to-noise ratio. We apply our deep denoising autoencoder on synthetic and real single-station cross-correlation functions computed from a few MeSO-net stations located in the Tokyo Metropolitan area. The denoised waveforms allow us to compute more precise relative velocity change (dv/v) than with the raw waveforms. The great advantage of this technique is that the algorithm can be trained within a few seconds and can be used to denoise near-real-time data, which could be useful for volcano monitoring.

Keywords: Seismic noise, Deep Autoencoders, Green's function

