Passive surface waves classification using deep convolutional neural network

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Passive seismic measurement has been intensively studied for the purpose to make up the shortage of the active measurement. In highly populated urban areas, the passive surface wave methods particularly grasp its chance to blossom because traditional geophysics surveys cannot be properly applied. Compared with the active surface wave methods, the passive surface wave methods possess the following advantages ① to complement active survey methods by exploring greater depth due to an extending the source spectrum to lower frequencies; ② to save costs associated with active sources in field operations; ③ to monitor the long term mechanical evolution of structures and grounds in civil engineering scale.

Despite the clear trend in implementing the passive surface wave methods to characterize underground structure on multiple scale, challenges still exist because of the non-stationary noise source distribution. Due to logistical constraints, passive seismic acquisition in urban areas is mostly limited to short recording periods. Non-stationary sources contributions would not be cancelled out because of insufficient temporal averaging, which would introduce artifacts and smear the dispersion spectra during passive surface wave dispersion imaging. In order to improve the dispersion imaging, most recent studies focus on new data processing scheme or dispersion imaging scheme. Cheng et al. (2018a) first presented a data selection strategy to classify passive surface waves and attenuate the "crossed" artifacts using a FK-based filtering technique. It focuses on the "crossed" artifacts that are due to bidirectional passive surface waves and occur at high-frequency band (> 5 Hz) of the dispersion spectra. In order to cover the shortage of Cheng et al. (2018a) on low-frequency (< 5 Hz) artifacts attenuation, Cheng et al. (2018b) further proposed a τp-based data selection technique which focuses on the "high-velocity" artifacts that are caused by the crosstalk of events with different incoming directions. In addition, Zhou et al. (2018) and Pang et al. (in review) indicate that data selection techniques based on time-domain cross-correlations also prove their ability and effectivity on improving passive surface wave imaging. Above four works or any other unknown works present different technique with different input data based on different domain but equally satisfy the same purpose for passive surface waves classification. However, we have to face the following challenge: ① Which one technique should be employed on one new dataset? ② Is there one technique that could be able to solve all problems? ③ Is it possible to combine all above techniques to obtain the optimum performance?

One solution is to use the machine learning based method, which has been increasing applied for various seismic facies recognition tasks. In this work, we show automatically-generated labels from above techniques can be effectively used to train deep learning models for passive surface waves classification. To achieve this, we independently use above four techniques to automatically generate labels, and modify the network's loss function to weight the confidence on the labels from different techniques to reduce false positives. It indicates that the machine learning based method could be able to coordinate different filter rules and directly classify passive surface waves on the original time-offset (*x*-*t*) domain.

References

Cheng, F., Xia, J., Xu, Z., and Mi, B., 2018a, Frequency-wavenumber (FK)-based data selection in high-frequency passive surface wave survey: Surveys in Geophysics, 39(4), 661-682.

Cheng, F., Xia, J., Behm, M., Hu, Y., and Pang, J. 2018b. Taup-based Data Selection in High-Frequency Passive Surface Wave Survey: Towards Traffic Noise: SEG Extend Abstract: 3077-3081.

Pang, J., Cheng, F., Dai, T., and Ning, L., in review, Automatic time-domain data selection for imaging near-surface passive surface waves: Journal of Applied Geophysics.

Zhou, C., Xi, C., Pang, J., and Liu, Y., 2018, Ambient noise data selection based on the asymmetry of cross-correlation functions for near surface applications: Journal of Applied Geophysics, 159, 803-813.