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Using low-cost seismometers and machine learning on earthquake early warning

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Earthquake early warning (EEW) plays an important role in earthquake disaster mitigation. There are two types of EEW system, regional and on-site. On-site EEW systems analyze initial part of the seismic waves from the P-waves to predict later ground motion from the S-waves and surface waves. In recent years, an on-site EEW method based on fixed peak displacement (Pd) threshold is developed. Although the method consistently provides effective warnings in Taiwan, several studies suggest that its strong filter dependence might introduce extra biases to the system. Also, the fixed Pd threshold suffers from the inevitable trade-off between a false alarm and a missed alarm. In order to overcome the abovementioned problems of fixed Pd threshold method, we utilize techniques in machine learning and develop a new method of on-site early warning. Owing to the property that convoluted-neural-network (CNN) will automatic sampling on different frequencies, the unfiltered seismic signal itself is sufficient to derive a warning threshold. Also, multi-layered neural-network is capable of forming a complex non-linear threshold to reduce both the false alarms and missed alarms. As an example, we collect 21 medium to large inland earthquakes in Taiwan. We compare the performance between the proposed method and the fixed Pd threshold method. The result shows that the proposed method outperforms in both false alarm rate (0.01 percent) and missed alarm rate (30 percent). The proposed method can provide not only significant improvements for on-site EEW but also a window into the initial P-waves. Studying the trained models might even reveal the hidden indicators inside the initial P-waves.

Keywords: earthquake disaster mitigation, on-site type earthquake early warning, machine learning