Robust seismic phase detection method modeling both global and local representations of waveform

*Tomoki Tokuda[1], Hiromichi Nagao[1]

1. ERI, The University of Tokyo

Detection of earthquakes is a fundamental prerequisite for seismology, contributing to various research such as evaluation of seismicity and understanding crust/mantle structures. With highly sensitive seismometers installed in various locations in the world, modern seismology allows us to detect not only large earthquakes, but also very small ones that one may not feel in normal circumstances. So far, several methods have been proposed to detect earthquakes using seismometer data. A classic method is based on the short term over long-term averages of waveforms (STA/LTA) method. Combining an auto-regressive model, it enables us to effectively infer a P-wave arriving time. Recently, more powerful detection methods have been proposed using deep-learning approach such as convolutional neural network (CNN), phase network and recurrent neural network. In the present talk, we propose a novel method based on CNN, which extends the generalized seismic phase detection method (GPD; Ross et al, BSSA, 2018) to multi-region CNN model (Gidaris & Komodakis, ICCV, 2015). First, we identify relevant regions of seismic waveforms for phase detection by means of applying a multiple clustering method. Based on the clustering result, we consider multiple CNN models for global and local parts of the waveform. Second, we combine phase detection probabilities yielded from these models, which defines an overall probability for phase detection. Compared with GPD, our method yields robust detection of seismic phase, which is demonstrated by application to a benchmark dataset. Next, we apply our method to continuous seismic waveform data, taking an example of 2016 Bombay beach swarm. It is shown that our method can effectively detect seismic phases after the onset of the swarm, while it correctly detects little seismic phase before the onset. Finally, we show the flexibility of our model, which can be readily adapted to detect low-frequency earthquakes without further training the model.