Detection of Deep Low-Frequency Tremors from Continuous Paper Records at a Station in Southwest Japan About 50 Years Ago Based on Convolutional Neural Network for Seismogram Images

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The establishment of the High Sensitivity Seismograph Network (Hi-net) in Japan has led to the discovery of deep low-frequency tremors. Since such tremors are considered to be related to large earthquakes adjacent to tremors on the same subducting plate interface, it is important in seismology to investigate tremors before establishing modern seismograph networks that record seismic data digitally. We propose a deep learning method to detect evidence of tremors from seismogram images recorded on paper more than 50 years ago. In our previous study, we constructed a convolutional neural network (CNN) based on the Residual Network (ResNet) structure and verified its performance through learning with synthetic images generated based on past seismograms. In this study, we trained the CNN with seismogram images converted from real seismic data recorded by Hi-net. The CNN trained by fine-tuning achieved an accuracy of 98.64% for determining whether an input image contains tremors. The Gradient-weighted Class Activation Mapping (Grad-CAM) heatmaps to visualize model predictions indicate that the CNN successfully detects tremors without affections of a variety of noises, such as teleseisms. The trained CNN was applied to the past seismograms recorded at the Kumano observatory, Japan, operated by Earthquake Research Institute, The University of Tokyo. The CNN shows the potential to detect tremors from past seismogram images for broader applications, such as publishing a new tremor catalog.

