Detecting Earthquakes in Noisy Real-Time GNSS Data with Machine Learning for Earthquake and Tsunami Early Warning

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Real-time Global Navigation Satellite Systems (GNSS) data are an important source of information about earthquakes as they occur, as they do not saturate in the near field with high magnitudes as broadband seismic data do. For this reason, integration of real-time GNSS data into earthquake monitoring systems such as tsunami and earthquake early warning (EW) has been a subject of great interest. However, GNSS data have a much higher noise floor (~1-5 cm) than traditional seismic data, especially in real-time, making it difficult to identify the early onset signals of events. Here we show the performance of a machine learning algorithm for identifying earthquakes in real-time GNSS data by modifying an existing convolutional neural network (CNN) code designed for picking P-waves in seismic data. This CNN was trained using realistic synthetic earthquake waveforms modeled using the faults associated with the Ridgecrest Sequence, as well as real-time noise from the UNAVCO-operated Network of the Americas (NOTA) GNSS stations around Ridgecrest. From preliminary testing of the CNN using synthetic waveforms which it had never seen in training, the model's general accuracy when identifying earthquakes was around 98% for the entire dataset. For waveforms with peak ground displacements (PGDs) above 10 cm, we achieved 100% accuracy. The algorithm has also shown initial success in identifying earthquakes in real UNAVCO NOTA position solutions covering the time period of the Ridgecrest earthquake sequence, and statistical analysis of these results is ongoing. These position solutions are the same types of data that an EW system would receive, so the success of this method could have implications for how real-time GNSS data are incorporated into earthquake monitoring systems.

July 6, 2019: Ridgecrest **M**7.1 – CNN prediction for station BEPK