Microearthquake Detection from Template Matching to Machine Learning

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Recent advancements in seismic instrumentations around the world provide an unprecedented opportunity to unravel detailed structures of the Earth's interior and decipher earthquake processes. While many earthquakes have been routinely picked by seismic network analysts, a significant fraction of them are still missing, especially during intensive earthquake swarms, episodic tremor and slip, or foreshock/aftershock sequences. These missing events could be detected by a template matching method, which uses waveforms of existing events as templates to scan through continuous data for new events with high similarities. In this talk I first report our group's recent efforts to use this method to systematically detect regular and slow low-frequency microearthquakes along major plate-boundary faults. Our results show that transient stresses on the order of a few kilopascals are capable of triggering fault slip at long-range distances, suggesting that earthquakes and faults are better connected than previously thought. These newly detected events help to better illuminate fault interfaces ruptured during large earthquakes, and how faults relieve stresses in fast and slow slips. Next I discuss how to go beyond template-matching methods and use network-based similarity and machine-learning techniques to pick seismic phases from large continuous waveforms. Unlike other deep learning methods that requires up to millions of accurately picked phases as labels, our method based on convolutional neural networks (CNNs) can be trained a relatively small labeled dataset. In addition, they can be applied to other regions with small modifications, suggesting that machine-learning based methods are more general than template matching methods and have great potential for detecting new seismic events from continuous waveforms.

Biography

Dr. Zhigang Peng is a professor of geophysics in the School of Earth and Atmospheric Sciences at Georgia Institute of Technology. His research mainly focuses on active fault zone structures and earthquake physics. Over the past 13 years, he has received a total of more than $2 million research funding from National Science Foundation (NSF), United States Geologic Survey (USGS), National Aeronautics and Space Administration (NASA), and Southern California Earthquake Center (SCEC). Dr. Peng has published more than 100 papers in peer-reviewed journals such as Nature Geoscience, Science, Journal of Geophysical Research (JGR), Geophysical Research Letters, etc. His H-index is 34 (from Google Scholar), and his research results have been widely reported by major news and scientific media around the world. He was an associate editor for both JGR and Bulletin of Seismological Society of America from 2011 to 2013, and the editor-in-chief for Seismological Research Letters from 2013 to 2019. He is currently serving as the Board of Directors for the Incorporated Research Institution for Seismology (IRIS), and the vice president of the Eastern Section of the Seismological Society of America. Dr. Peng is a recipient of the NSF CAREER award in 2010, the Charles Richter Award from the Seismological Society of America (SSA), and the Young Faculty award from the School of Earth and Atmospheric Sciences.

Dr. Peng was born in 1975 in Meishan City, Sichuan Province, China. He got his B.S. from University of Science of Technology of China in 1998 and his Ph.D. from University of Southern California in 2004.