



A new neural network approach for seismic event detection

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Applications could expand to surveillance, scientific discovery, and data cleaning.

In a first-of-its-kind approach, scientists at Los Alamos National Laboratory have applied what is known as a “deep dense neural network” approach to the detection of seismic events.

“In a nutshell, our method identifies events of interest, earthquake signals, from 1-D time series data in a supervised manner,” said Youzuo Lin of the Los Alamos Earth and Environmental Sciences division. “Our approach, called DeepDetect, could be adapted to other domains of applications, such as surveillance, scientific discovery, and data cleaning, which all involve monitoring routinely collected data,” Lin said.

“We have already started to explore the broader potential by applying this technique to several important subsurface applications including first, detection of the leakage of carbon sequestration in the subsurface; and second, detection of the induced seismicity caused by fluid injection practices,” Lin said.

The research as applied to seismic events is described in a paper in the journal [IEEE Transactions on Geoscience and Remote Sensing \(IEEE-TGRS\)](#) this week.

Using acoustic data generated from the Pennsylvania State University Rock and Sediment Mechanics Laboratory, the team proposed a novel cascaded region-based convolutional neural network to capture events in different sizes, while incorporating contextual information to improve the detection accuracy.

The DeepDetect neural network design is based on a programming approach that mimics the biological pathways in an animal brain, rather than providing the computer with step-by-step instructions to solve a problem. With a deep, dense neural network, the system has multiple layers of information to assess, progressively developing complexity as each layer is juxtaposed over another.

The system develops its own understanding of how to interpret the data in phases, aided by expert human labeling at key points, and working toward more accurate interpretations as the layers build up. In this case, earthquake data is analyzed as a sequence of data points taken at successive equally spaced points in time. The goal is to achieve an efficient, accurate, and cost-effective method to detect events of interest based on previously observed data.

The data used for the machine learning model comes from a frictional experiment in the Pennsylvania State University Rock and Sediment Mechanics Laboratory, using the “double-direct shear configuration” where two laboratory fault zones are sandwiched between two forcing blocks and sheared simultaneously. The continuous acoustical signals from the experiment were recorded and from this signal, an earthquake catalog was assembled. A full 1,000 earthquakes were selected, representing signals from within the first 2 seconds of the quake’s stick-slip cycle. The team used 800 event signals for training the system, then 100 more for testing and 100 more for validating.

The paper: “[DeepDetect: A Cascaded Region-based Densely Connected Network for Seismic Event Detection](#),” Y. Wu, Y. Lin, Z. Zhou, D. C. Bolton, J. Liu and P. Johnson, *IEEE Transactions on Geoscience and Remote Sensing*.

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