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CS35L

Project 10

Machine Learning Predicts Laboratory Earthquakes

Methods of pinpointing when earthquakes will occur have been largely ineffective in the past. The main way of predicting when an earthquake would strike was by measuring how frequently earthquakes occurred at a specific fault and then using seismic data to determine exactly how long that interval was. However, because volcanic activity and the movement of Earth's crust is dynamic, these predictions were often wrong. For example, in the Cascadia subduction zone, the seismic data predicted that an earthquake would occur every 29.1 ± 3.1 years. Since there was an earthquake in 1966, the next earthquake should have occurred between 1988 and 1993 (Rouet- Leduc, Bertrand, et al). However, they were wrong, for the next earthquake did not occur until 2004. Therefore, researchers from the University of Cambridge, Boston University, and Los Alamos National Laboratory developed a machine learning algorithm to help better predict when earthquakes would occur.

There are distinct acoustic and seismic precursors that occur before every earthquake. However, most of this data had been disregarded because the differences were so small that they were left unnoticed. However, researchers from this study studied this minuta and measured the amount of energy emitted from the faults. Using the data they collected, they were able to develop a machine learning algorithm that would identify the sound pattern to estimate the amount of stress on the fault, the amount of energy at the fault, and the time remaining before failure (an occurrence of an earthquake). In a laboratory setting, researchers used steel blocks of

160 GPa calibur to resemble the fault and a driving piston that worked at a resting pace of 5 µm/s to represent the energy emitted from the Earth's Crust during seismic movement.

The scientists tested the machine learning algorithm to measure the acoustic information (which represented the strain at the fault). As shown in Figure 1, there always is a larger outburst of this acoustic and seismic activity right before an earthquake occurs. Using this measurements, the algorithm would use a decision tree shown in Figure 2 (which tracked the possibilities of an earthquake happening) to determine when the next earthquake would occur. The algorithm would then tell researchers the likelihood of an occurrence of an earthquake.

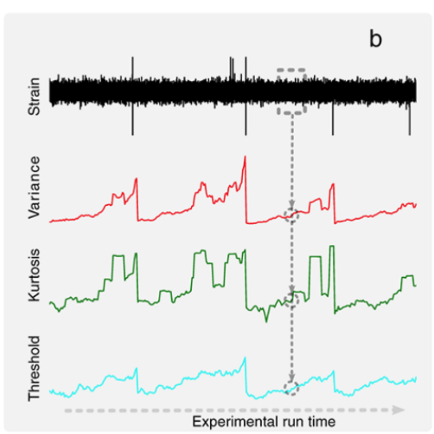

Figure 1

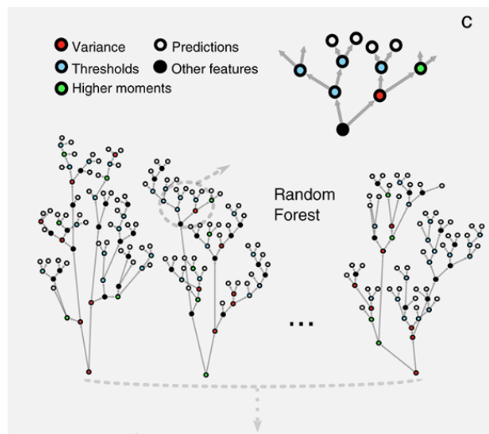

Figure 2

Figure 3 below shows the results of the experiment. The dotted red line represents the actual time to failure (occurrence of earthquakes). After accurately predicting the probability of an earthquake between short cycles (small time differences between earthquakes), long cycles (large time differences between earthquakes), and aperiodic cycles (sporadic time differences between earthquakes) with a 90% accuracy rate, researchers were able to conclude that this machine learning algorithm could be the solution to better predict when earthquakes occur (Rouet- Leduc, Bertrand, et al).

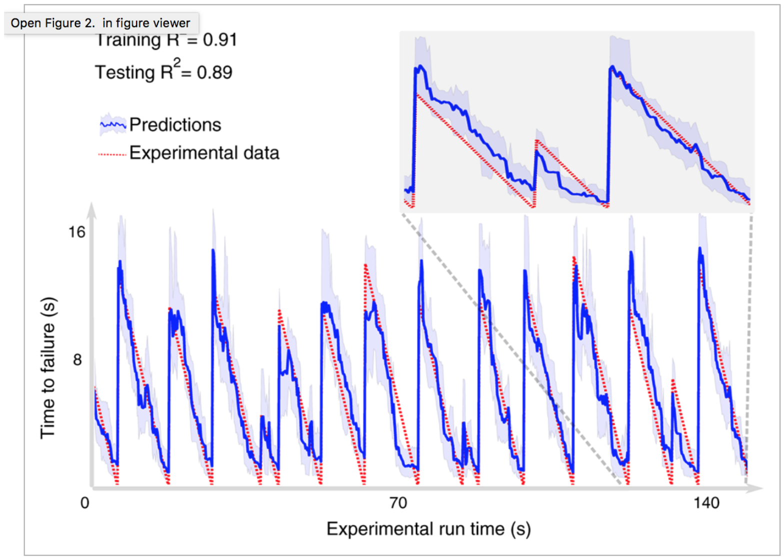

Figure 3

Because these tests have only been run in a laboratory setting and do not account for all of the external variables of Mother Nature in the real world, the researchers on this experiment are looking into moving these tests to real earthquake faults. For example, the San Andreas Fault emits constant, small earthquakes (similar to that of the laboratory condition), which the algorithm is accustomed to and can therefore make predictions about the occurrences of seismic activity at this location. Once applied to the real world, this algorithm could be used to predict earthquakes at every fault to help human populations living in those areas better prepare for an earthquake. In 2015 alone, 9,624 alone people died as a result of earthquakes ("Deaths Due to Earthquakes…"). If we could more accurately predict when they would occur, individuals would have time to take shelter or safely remove themselves from a dangerous situation.

I believe that this research is an avant-garde approach in understanding earthquakes. As the first application of machine learning to process continuous seismic data, this methodology of predicting earthquakes requires no human intervention -- removing human bias and external variables from the question. It is revolutionary in the fact that it uses a new methodology of combining acoustic and seismic activity as indicators of strong seismic activity since they are always precursors of earthquakes. Machine learning has the ability to grow, adapt and change as the Earth’s crust moves, and this solution could be the one needed to counteract the mass destruction of earthquakes.

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