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Not My Fault: Artificial Intelligence in the earthquake and tsunami world

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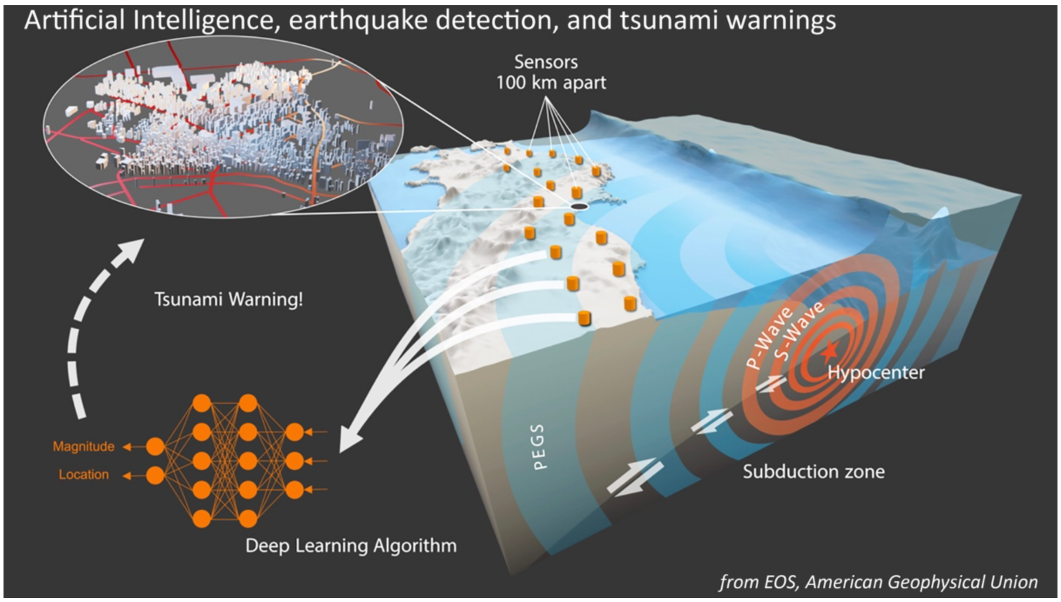

How artificial intelligence might improve tsunami forecasts. The system stores historic and simulated earthquake and tsunami characteristics. A network of instruments monitors events. Algorithms draw on the data to forecast wave characteristics after only a few minutes of real data (EOS, American Geophysical Union).

I know very little about Artificial Intelligence. From media headlines, AI can sound like the greatest threat to human society or the solution to many problems. I thought it worth digging into a bit and see how it might work in areas I do know something about.

If you are like me, you probably know AI has something to do with algorithms and can forecast outcomes, but perhaps not much more. I dug into a little AI basics to better understand how it is being applied to earthquake detection, early warning, prediction, and tsunami forecasting.

Computers and algorithms have been a part of seismology for over half a century. In my early years in graduate school in the late 60s, I lugged boxes of punch cards over to the computer center, picking them up several hours later often only to discover a fatal error that prevented the completion of my run. Mine was the only intelligence involved and often I found it lacking.

The critical advance in AI is the ability of the program to learn and adapt without human intervention. To do so requires vast quantities of information about the task at hand – the machine learning part of the process. Traditional programing like I was doing with my stacks of punch cards is like cooking. You carefully define what goes into the recipe, giving a detailed set of instructions on what the computer is supposed to do with the data you have supplied.

Machine learning (ML) is the "training" part of the AI process, loading an enormous amount of data into the system and identifying any number of patterns. Spam phone call recognition is an example that anyone with a smartphone uses on a daily basis. The data set is phone numbers and past behavior. Some numbers can be identified as belonging to marketing companies. Others are identified from message content and users' behavior. Every time you or anyone else marks a message as spam, it goes into the larger data base and the next time it is used, it is flagged as potential spam. ML allows the system to learn new things as it acquires more data.

The AI step is the algorithms telling the computers what to do with all the data that has been acquired. With spam phone calls or email, it is a relatively straightforward process of announcing the spam call or sending it to a spam folder. It's not a perfect system. I take a quick glance at my spam folder every week or so to see if something important has ended up there, but the errors have been few.

There are many other AI/ML applications that are already a part of your everyday life. Your bank or financial institution is using AI to identify fraudulent transactions and healthcare systems are including it in diagnosis and treatment options. If you use social media, the ads that pop up on your feed are based on what you click on or hide. I like crosswords and sometimes my search for a hip hop star or unusual item of clothing has directly resulted in a surge of unusual ad posts.

AI can be used as a descriptive tool, to better understand what has actually happened, as a predictor of what is most likely to happen next, or to make suggestions as what options are available in decision making. No matter what the application, the accuracy and usefulness is a function of the data it is based on - quantity and quality count!

Turning to seismology, my quick glance at the GEOBASE reference index comes up with 400 citations including AI or ML in the past five years. They cover a wide range of applications such as identifying small earthquakes and aftershocks in noisy environments, relationships among source and rupture characteristics, forecasting ground motions, and identifying previously unnoticed signals that might give insight into source dynamics.

The topic that has gotten both the most media and research attention is using AI/ML as an earthquake prediction tool. Predicting the location and size of an earthquake days to weeks in advance has been the holy grail of seismology for more than a century. A 1913 Scientific American article proclaimed, "Earthquake Prediction Right Around the Corner." That corner has turned out to be a very large one.

The USGS ShakeAlert™ system does a good job of predicting felt earthquakes in the few seconds AFTER the rupture has begun and before the strongest shaking reaches you. This is a big advance that allows for critical systems to power down and people to Drop, Cover, and Hold ON. But as of today, we have no reliable way to issue accurate alerts for a longer time window.

The idea behind using AI/ML is to identify subtle patterns that could lead to forecasts with a longer lead time.   There are many different approaches being used, some taking a laboratory approach, others using GPS data of sensitive land level changes, electromagnetic signals, seismicity patterns, or slow slip events.

China is a global leader in AI-driven earthquake forecasting. An international contest hosted by China drew 600 entrants from around the world. A team from the University of Texas took first place, accurately predicting 70% of earthquakes during a seven-month trial in China. They used historic earthquake data and developed pattern recognition algorithms to issue predictions. The Texas team accurately estimated magnitude and forecasted locations of 14 moderate earthquakes within 200 miles of the actual epicenter.

While the achievement received accolades and media attention, it is by no means ready for prime time. In the same time window, it issued eight false warnings and missed one quake completely. Predictions only become actionable with a much higher level of accuracy.

My interest in AI/ML was peaked after listened to a talk last week on applications to tsunami forecasting. Chris Moore of NOAA is working on improving estimates of tsunami wave heights by using the first few minutes of the tsunami wave train on deep ocean instruments. Tsunamis are problematic because the distribution of real time and space is so limited. His team augmented to the actual data by creating simulated sources from all over the Pacific.

By training the program with thousands of simulated earthquakes, the group was able to get very accurate forecasts of the entire wave train by looking at only 12 minutes of real data. This could have implications for us the next time a great quake occurs somewhere in the Pacific by not only telling us the arrival time of the first surge, but the second, third, fourth, and later ones, and which one is likely to be the largest.

No matter how rosy a future for AI in the earth sciences, ground shaking that lasts a long time will still be my warning to get out of the tsunami hazard zone.

Note: for a more detailed overview of AI and machine learning, visit
https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained

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