NH33A-04 Nowcasting Earthquakes with QuakeGPT: An AI-Enhanced Earthquake Generative Pretrained Transformer

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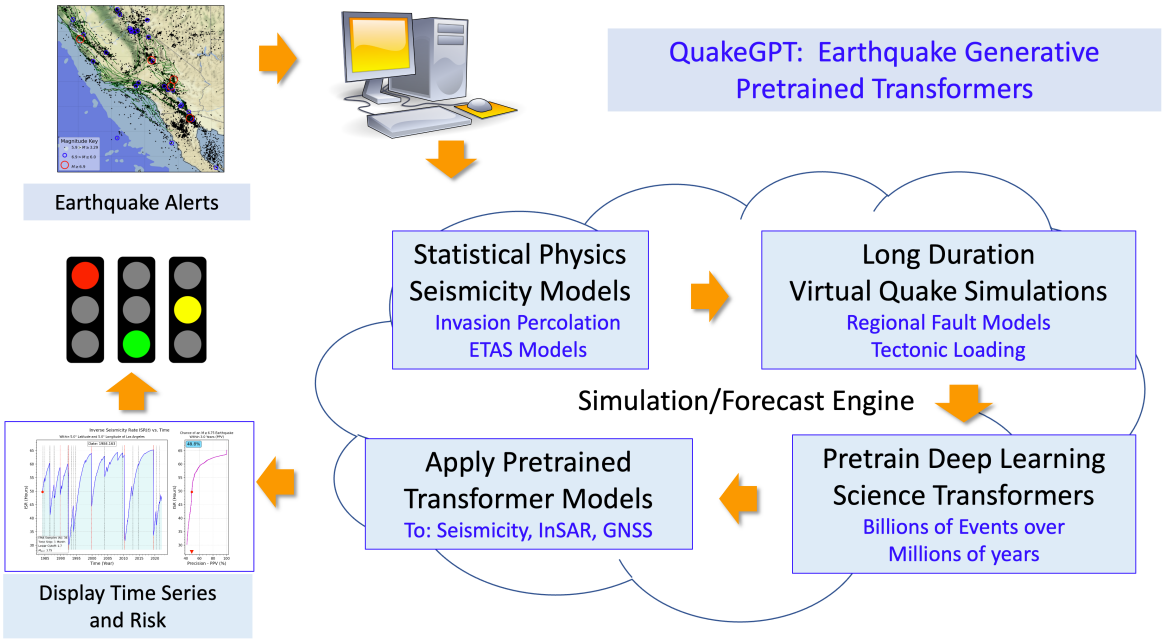
Abstract

We are developing a new approach to earthquake nowcasting based on science transformers (GC Fox et al., Geohazards, 2022). As explained in the seminal paper by Vaswani et al. (NIPS, 2017), a transformer is a type of deep learning model that learns the context of a set of time series values by means of tracking the relationships in a sequence of data, such as the words in a sentence. Transformers extend deep learning in the adoption of a context-sensitive protocol "attention", which is used to tag important sequences of data, and to identify relationships between those tagged data. Pretrained transformers are the foundational technology that underpins the new AI models ChatGPT (Generative Pretrained Transformers) from openAI.com, and Bard, from Google.com. In our case, we hypothesize that a transformer might be able to learn the sequence of events leading up to a major earthquake. Typically, the data used to train the model is in the billions or larger, so these models, when applied to earthquake problems, need the size of data sets that only long numerical earthquake simulations can provide. In this research, we are developing the Earthquake Generative Pretrained Transformer model, "QuakeGPT", in a similar vein. For simulations, we are using simulation catalogs from the physics-based model Virtual Quake, the statistical model ETAS, and a statistical physics model based on invasion percolation. Observed data, which is the data to anticipate with nowcasting, is taken from the USGS online catalog for California. In this talk, we discuss the architecture of QuakeGPT and report first results. We also report results using other types of simulated seismicity such as slider block models, to quantify how well a

lack of knowledge of the underlying physics affects the results obtained.



Plain-language Summary

Generative earthquake seismicity models will be used to train deep learning codes used for artificial intelligence (AI) and machine learning (ML), leading to a process of earthquake anticipation ("nowcasting") via a science transformer model "QuakeGPT". These deep learning computer codes use the mechanism of "attention" that is used in the AI code ChatGPT. To anticipate earthquakes, we need to train the transformer models on simulation data for millions of years, data timescales that we do not have. For that reason, we are developing earthquake simulations to train the models, which will then be applied to the several decades of observed data. One of these models is the Virtual Quake code, a physics-based code. Another of these methods of simulation is based on the popular Epidemic Type Aftershock Sequence (ETAS) model, which uses the primary laws of observed seismicity to reproduce simulated data. As part of the process of building these codes, we have used the AI code ChatGPT to write portions of the python codes. We have also developed a series of science transformer codes that we describe in this talk, together with first results.

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