ARMA Future Leader Webinar Series

Every Two Weeks on Fridays 9-10 am MT (11 am – 12 pm ET)

On the Practical Use of Machine Learning for Predicting Fault Behavior and Induced Seismicity from Underground Laboratories to Oklahoma

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https://stonybrook.zoom.us/j/9539339965?omn=96069259795

Abstract

Machine learning (ML) has been increasingly used in recent years to address problems in rock mechanics and earth science. With advanced geophysical, geological, hydrological monitoring and sensing techniques, data that covers different spatial and temporal scales has been collected in underground research laboratories (URLs) and in other field settings relevant to subsurface energy geoscience applications. To make machine learning practical, the key questions are: Can we use the simplest machine learning model with the least amount of data to make reliable predictions? For irreversible and complex behavior (such as fault seismic and aseismic slip), what can we learn from mismatches? Can machine learning be used for assisting and guiding geophysical monitoring and sensing in the field from meters to kilometers, from micro-seconds to years? To answer these questions, we use machine learning to analyze data and system behavior from several URLs (e.g., Mont Terri in Switzerland and EGS Collab in South Dakota) to Oklahoma (at the basin scale). Collaborations with geophysicists and geologists were an essential part of this effort. The machine learning applications included the use of different convolutional neural networks (CNN) for recognizing multiscale features from Mt Terri URL, the use of a long short-term model (LSTM) to predict fault responses to fluid injection in Mt Terri URL, and the use of LSTM to predict spatiotemporal microearthquakes in EGS Collab. Last, we show the use of a novel approach based on a simple neural network to predict basin-scale injection-induced seismicity in Oklahoma in both space and time. From these ML projects, we highlighted the important aspects needed for good predictions when complex behavior and/or a massive amount of data with mixed quality is encountered. We show promising and practical alternative approaches for detecting fault slip and seismic events from geological to multi-physical responses.

Bio

Dr. Mengsu Hu is a Research Scientist at the Lawrence Berkeley National Laboratory (LBNL). Her research focuses on multiscale numerical modeling and machine learning for analyzing coupled thermal-hydro-mechanical-chemical (THMC) processes, with application ranging from fundamental Earth science to subsurface engineering systems (e.g., nuclear waste disposal, geothermal energy, and geologic hydrogen production and storage). Her numerical approaches have been applied to solve a range of coupled processes problems in fundamental and applied geosciences programs. She has raised funding for and led several Department of Energy (DOE) multidisciplinary and multi-PI projects. Dr. Hu was one of the founding co-chairs of the CouFrac conferences. Currently, Dr. Hu is serving on the Board of Directors of American Rock Mechanics Association (ARMA). She has been invited to serve on the Editorial Board for Rock Mechanics and Rock Engineering (Associate Editor), PNAS Nexus of the National Academy of Sciences (NAS), International Journal of Rock Mechanics and Mining Sciences, and Geomechanics and Geophysics for Geo-Energy and Geo-Resources. In 2022, Dr. Hu was selected as a participant of National Academy of Engineering (NAE) U.S. Frontiers of Engineering symposium.