PEER
PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Research Highlight

Informing Predictions from Above with Community Data from Below: A Hierarchical AI Liquefaction Model for Rapid Response and Simulation

Project # NCTR-1185-NCTRMB

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Abstract

Imagine a world where coseismic impacts are accurately predicted as they occur, both at high spatial resolution and at regional scale. By corollary, these predictions could also be made for scenario events – rapidly and inexpensively – anywhere desired. To be “accurate,” such predictions require accurate models of response, but also accurate characterizations of the systems that respond. While this vision is very slowly becoming reality, progress has lagged for the problem of soil liquefaction. Specifically, state-of-practice liquefaction models require expensive, site-specific data, such as that from the cone-penetration-test (CPT). This is a challenge to large-scale simulations, given the infeasibility of in-situ testing across vast areas. Hence, the problem of knowing what will respond is at least as difficult as predicting how it will respond. To that end, this project will exploit growing community geotechnical datasets and dense geospatial information to deliver a mechanics-informed machine learning (ML) model that will conceptually and measurably improve regional-scale prediction of liquefaction impacts. The ML model will learn to predict subsurface conditions remotely using 30+ geospatial predictors and will be anchored to established geotechnical models, thereby ensuring mechanistically sensible scaling and response. Simultaneously, predictions will be anchored to CPT sites in the field via regression kriging, thereby ground-truthing ML to reality and benefitting from shared geotechnical data.

Deliverables

This project will deliver a hierarchical, mechanics-informed ML liquefaction model for rapid response and simulation, wherein predictions are updated via geostatistics in the vicinity of CPTs. This approach will merge: (i) large and rapidly growing geotechnical test datasets; (ii) geotechnical liquefaction models; (iii) dense geospatial data from satellite sensing and existing maps; and (iv) algorithmic learning. The model will be trained, tested, and anchored using data from the PEER domain, and will be embedded in a high-resolution map. The mapped values, once convolved with a ShakeMap, make probabilistic prediction of liquefaction trivial. The development and use of the model will be presented in a PEER report and in other research publications.

Research Impact

PEER has heavily invested in tools for improved earthquake simulation, planning, and rapid response (e.g., in the context of bridges and transportation corridors). This project will significantly advance our capacity to simulate liquefaction impacts, which has received less attention in the context of regional and near-real-time predictions. The proposed model has immediate applications including: (i) regional loss estimation and disaster simulation; (ii) city planning and policy development; and (iii) emergency response and reconnaissance, given that the model will have near-real-time prediction capabilities. Beyond these impacts, the research will grow the use of AI to predict subsurface conditions, which has many other applications.

Project Image

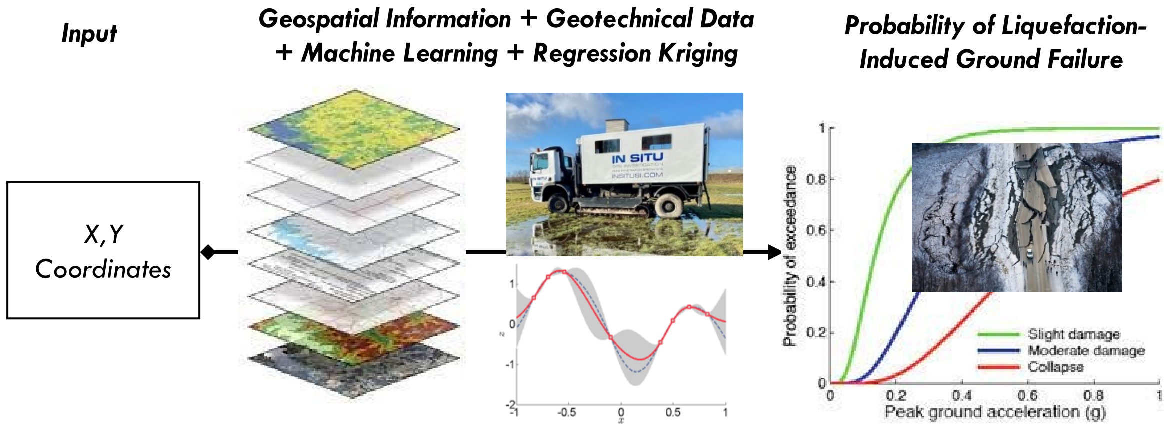

Figure. Synopsis of the approach to predict probability of liquefaction-induced ground failure.