Research Project Highlight

Deep learning-based surrogate modeling for uncertainty quantification in soil-structure interaction problems

TSRP Topic: M3 - Forward uncertainty quantification

Principal Investigator
Elnaz Seylabi, Assistant Professor of Civil and Environmental Engineering, University of Nevada, Reno

Research Team
TBD, Graduate Student Researcher, University of Nevada, Reno

Start-End Dates:
9/1/2021-9/1/2022

Abstract
Direct modeling of soil-structure interaction (SSI) problems calls for modeling the infrastructure, near-field soil, and boundaries/interfaces to translate the far-field earthquake excitation and absorb the scattered outgoing waves. On the other hand, a rigorous seismic performance assessment of SSI problems calls for considering and propagating uncertainties associated with the soil and structure properties and the excitation field characteristics. Monte Carlo-based methods are the commonly used approach for this purpose, which require running many forward simulations and can become computationally expensive and not practical for large-scale SSI systems. A viable solution to this problem is to replace the high-fidelity forward simulator with a surrogate model. Suppose one designs the surrogate correctly and trains it adequately. In that case, it can provide an accurate and fast approximation of the high-fidelity simulator to accelerate Monte Carlo-based uncertainty quantification (UQ) tasks. In this research, our primary goal is to determine the promises of deep learning-based models as a surrogate to approximate the time-dependent response of SSI direct models. Since the quantities of interest are time-dependent, the recurrent neural network is expected to perform better than other architectures, such as the multi-layer perceptron and convolutional neural network. We have already tested this architecture's predictive capability for a single degree of freedom system to emulate the system's dynamic response by mapping a given earthquake excitation time series, natural frequency, and damping ratio to the displacement time series. In this project, we will extend this work to elastodynamics and, more specifically, to SSI problems.

Deliverables
A PEER report and several conference and journal papers presenting the proposed deep learning approach and its results.

Research Project Highlight

Deep learning-based surrogate modeling for uncertainty quantification in soil-structure interaction problems

Research Impact

The ability to accelerate forward UQ in SSI problems can significantly improve our understanding of how uncertainties in the soil properties and the seismic wave-field affect the key statistics in the structural response and the surrounding soil. We expect to use achieved insights from this one-year project to lay out a roadmap for future research on developing practical and affordable methodologies for performance-based engineering of large-scale SSI and wave propagation problems in transportation systems. This, in turn, will create new opportunities to evaluate the methods adopted in practice for the analysis and design of such problems.

Project Images

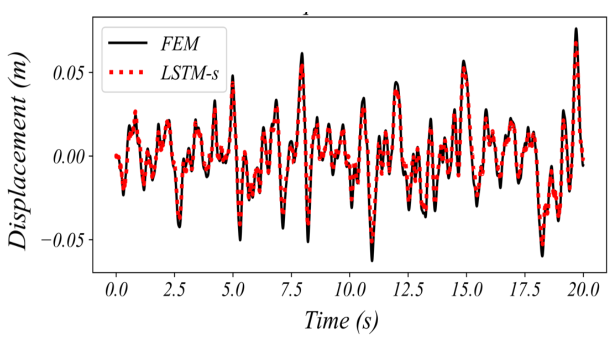

Figure 1 Surrogate model predictions for an SDOF system subjected to earthquake excitation.

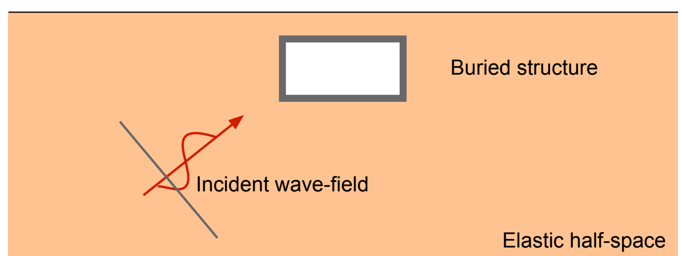

Figure 2 Schematic of the project testbed for surrogate modeling of SSI problems.

PEER Center – 325 Davis Hall, UC Berkeley, CA 94720 | peer_center@berkeley.edu