PEER
PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Research Project Highlight

Machine Learning for Analysis and Risk Management of Complex Infrastructure Systems

TSRP Topic: T4 - Complex models & large networks

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Start-End Dates:
8/01/2021- 8/01/2022

Abstract
This project aims to develop a neural network (NN) model for predicting the functionality of complex transportation networks and explore and demonstrate its utility for network risk management. We will first build a model to predict aggregate travel time on a network using the bridges' and roads' damage states as inputs. It will predict the impacts of bridge and road damage much more rapidly than traditional traffic assignment models. The speed is valuable when considering thousands of potential future earthquake scenarios in a risk assessment. We will then build a model to predict travel time increase risk, considering bridge damage as a function of the bridge fragility medians (and incorporating random future earthquake events in the training data. This model will be beneficial when coupled with optimization schemes to search for retrofit policies that reduce network risk. Those schemes are currently limited by the ability to efficiently link bridge properties and network risk. Additionally, we will explore the use of interpretable algorithms (e.g., the LIME algorithm) to process the trained neural network and identify bridges that strongly affect network performance.

Deliverables
Our deliverables will be the fitted models, and algorithms for identifying key features of the transportation model (shared on GitHub as standalone predictive models). We will share our fitted models with other PEER researchers and Caltrans to use for other needs. We will also produce journal publications documenting the approach and results.

Research Impact
A calibrated neural network model could significantly impact decision-making for agencies such as Caltrans. It would enable quick and convenient evaluation of the benefits of upgrading particular bridges and road links. Rather than requiring a detailed traffic assignment and routing calculation for each

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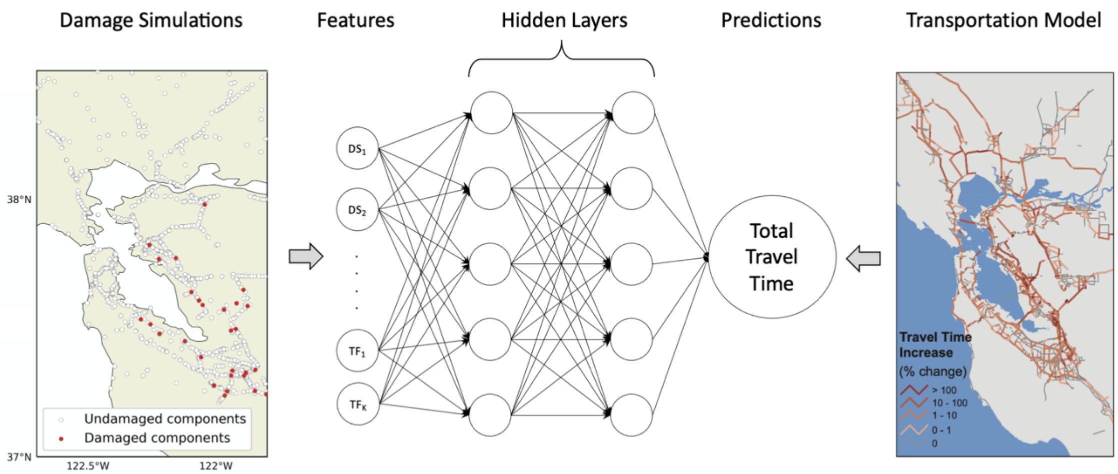
scenario, a fast and simple calculation could be made. This could enable network risk metrics to be considered in standardized evaluations of capital projects such as bridge retrofits or network upgrades. If interpretable algorithms such as LIME result in informative predictions of key components, that result could be of broad importance in showing the value of using machine learning algorithms to understand performance complex infrastructure networks.

Project Image



Overview of the Neural Network calibration approach. Training and test data consist of damage simulations and travel time calculations from a transportation model (far left and right of the graphic).

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