2ND UIC DIGITAL AWARDS

Software Framework:
Deep Learning for Accelerating Stochastic Assessment of Post- Hazard Railroad Infrastructure System Reliability

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In order to optimize mitigation, preparedness, response, and recovery procedures for railroad infrastructure systems, it is essential for the stakeholders and policy makers to use accurate and efficient means to evaluate system reliability against probabilistic events. Maximized post-hazard capacity utilization is a dominant objective to most rail sector decision makers.

The predominant approach to quantify the impact of natural disasters on railroad infrastructure remains to be the Monte Carlo approach, which still suffers from high computational cost, especially when applied to large systems. This project presents a straightforward software framework for accelerating simulation-based stochastic assessment of post-hazard railway infrastructure network reliability via deep learning.

The proposed framework enables fast risk assessment and real-time risk-informed decision making for large railroad infrastructure networks (containing links and bridges).

Furthermore, the proposed surrogates can be used for optimal seismic upgrades of railroad infrastructure components where decision makers seek to improve the reliability of infrastructure systems. In this case, typically in the face of budget constraints, it is crucial to identify the components that are most influential on the reliability measure and prioritize them for repair.

To evaluate the system performance, our framework will use inputs including railway network infrastructure system, link-dependent failure probability (for example: bridge failure probabilities), the demand for each location, etc.

Using the instances/samples generated by Monte Carlo simulation, a deep neural network will be trained to provide an accurate estimation of the railroad system reliability. The effectiveness and computation efficiency of our framework will be compared with Monte Carlo simulation approaches. Besides, we will conduct sensitivity analysis based on the deep neural network model to identify the most critical/vulnerable components in the railroad infrastructure network, which could help the agency in the decision-making process of the system upgrade or post-disaster restoration.

To demonstrate the applicability of our framework, we will apply our approach to simulation-based study. In this study, we evaluate the passenger on-board travel time in a California railway transportation network subject to extreme probabilistic earthquake events. Numerical results will highlight the effectiveness of the proposed surrogates in accelerating reliability analysis of infrastructures while achieving high prediction accuracy. Besides, for sensitivity analysis, the analytical derivation of gradients of the deep neural network could provide more insights of the system reliability compared with the numerical simulation-based results.

This software, will result in an output of prioritize railroad components based on their post-hazard failure severity probability.

- The prioritized components are further input to another optimization framework of the software for retrofitting schedule budget planning.
- Moreover, they can be input to capacity analysis framework for maximized post-hazard network capacity utilization.

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