[Poster]
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Surrogate model-based seismic risk assessment of bridge transportation networks

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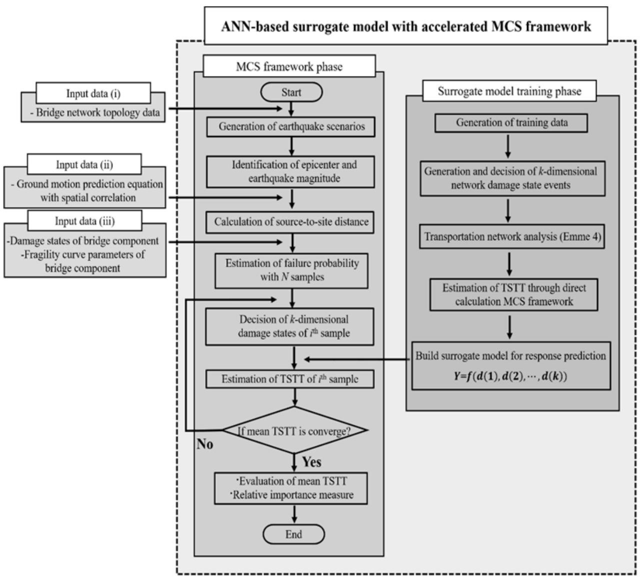
Abstract

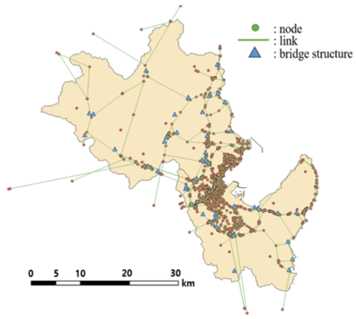
Conventional seismic risk assessment based on Monte Carlo simulation (MCS) may require a significant amount of computation time when dealing with a complex network (Tak et al. 2019). In this study, a surrogate model constructed using an artificial neural network (ANN) technique is introduced to accelerate the seismic risk assessment of a bridge transportation network. For surrogate model construction, the damage states of bridges are utilized as input data, and total system travel time (TSTT), which is recognized as a robust performance measure for transportation networks, is introduced and utilized as output data. To demonstrate the proposed methodology, an actual bridge transportation network in South Korea is adopted, and the network map is constructed based on GIS information. The corresponding analysis results show that the proposed methodology not only estimates the network performance accurately, but also provides a computationally-efficient procedure for probabilistic seismic hazard analysis.

Proposed method

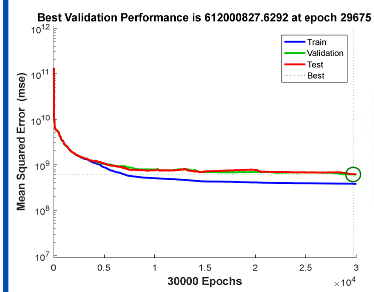


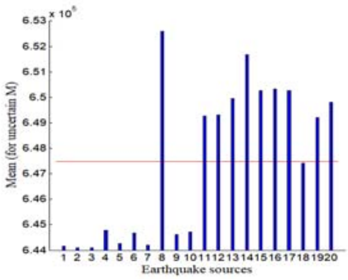
The figure shows a flowchart for ANN-based surrogate model with accelerated MCS framework (Yoon et al. 2020). The required input data for proposed method is the topology data of the target network, seismic attenuation law, and seismic fragility curve of component. If the failure probability is evaluated based on ground motion, the k-dimensional damage state matrix can be constructed. Finally, TSTT can be calculated through a surrogate model based on the ANN model which is pre-constructed using generated training data from trained epicenters and known TSTT results.

Application



The proposed methodology is applied to an actual bridge transportation network located in Pohang city, Korea (Yoon et al. 2020). The target bridge network consists of 1440 nodes and 3490 links, and bridge components connecting each road network consists of 48 long-span bridges, including highways and national highways.





For ANN training model, 30,000 epochs are considered for under-fitting and over-fitting problem with ratios of 0.7:0.15:0.15 (Train, Validation, Test set). The proposed method can calculate mean TSTT for uncertain earthquake magnitudes and locations over 20 epicenters with reduced time cost (Yoon et al. 2020). In addition, it has been confirmed that the larger the earthquake magnitude and the closer the epicenter is, the higher TSTT is needed.

Conclusion

Based on the numerical results of the proposed methodology to an actual bridge transportation network example, it has been demonstrated that the ANN based surrogate model enables not only prediction of the network performance accurately, but also efficient iterative computational procedures for probabilistic seismic hazard analysis.

Acknowledgement

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References

Tak, H.-Y., Suh, W., and Lee, Y.-J. (2019), "System-level seismic risk assessment of bridge transportation networks employing probabilistic seismic hazard analysis," *Math. Probl. Eng.*, **2019**, 6503616.

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