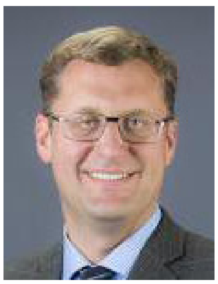
UNIVERSITY TRANSPORTATION CENTER

RESEARCH BRIEF

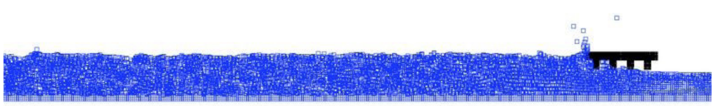
Physics-Informed Machine Learning of Fluid-Structure Interaction for Bridge Safety and Reliability

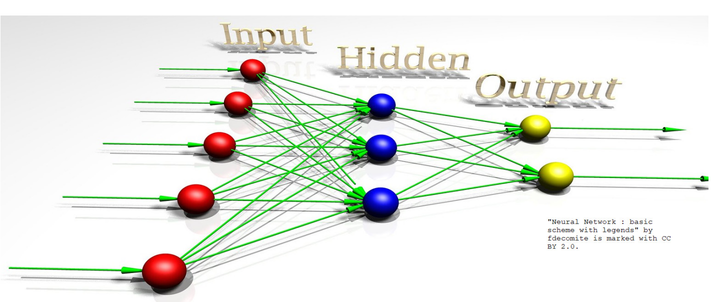
Michael H. Scott, PhD and Barbara G. Simpson, PhD



Background

Recent tsunami events have highlighted the vulnerability of bridges to hydrodynamic loading. For many coastal communities, bridges are the only regional transportation lifeline and are critical for the mobility of people, goods, and after a significant earthquake and tsunami event. To ensure reliable mobility after extreme events, it is necessary to understand, model, and design for bridge response under tsunami loading. However, simulation of FSI is computationally intense, involving both solid and fluid domains. While numerical methods for FSI and computing speed continually improve, more robust and faster computations are required to perform the parametric studies that shape modern bridge design codes for tsunami loading. Currently, refined FSI simulation is intractable for performing such studies due to computational cost. Recent advances in machine learning have led to reduced models able to “learn” complex physical processes that capture the essential features and physics of the original, full model. When provided with enough training data, machine learning algorithms can infer or discover input and output relationships, e.g., between tsunami flow conditions and bridge geometry (inputs) and bridge response (output). The resulting “reduced” models are faster and more efficient than computational FSI, enabling studies of bridges that are currently not feasible.





Research Project

The objective of this proposal is to use the FSI capabilities of the OpenSees finite element framework to develop a prototype machine learning algorithm for tsunami loading on bridge superstructures. To ensure robustness, the algorithm will be based on deep learning techniques using novel physics-informed neural networks. As the resulting input-output relationships from machine learning may not obey physical relationships, the learned models will be designed to retain the relevant physics of FSI, whereby momentum and mass balance are preserved throughout the training process by penalizing the learning process if the governing FSI equations are not satisfied.

ABOUT THE AUTHORS

The research team consisted of Michael Scott and Barbara Simpson of Oregon State University.

ABOUT THE FUNDERS

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EXPECTED DATE OF COMPLETION

March 2023

FOR MORE INFORMATION

https://depts.washington.edu/pactrans/research/projects/physics-informed-machine-learning-of-fluid-structure-interaction-for-bridge-safety-and-reliability/