UNIVERSITY TRANSPORTATION CENTER

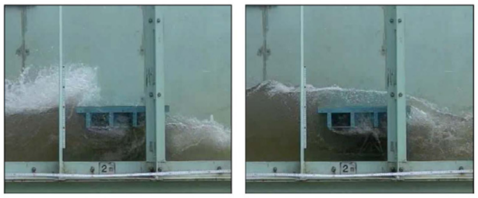
RESEARCH BRIEF

Pilot Study: Learning Fluid-Structure Interaction via Machine Learning

Barbara Simpson, PhD, Michael Scott, PhD

Background

In 2011, the Tohoku tsunami in Japan damaged over 250 bridges, hindering emergency response and delaying post-event recovery. Some bridges survived the earthquake but failed under the hydrodynamic demands induced by the subsequent tsunami. As similar hazards exist on the west coast of the United States, coastal bridges in the U.S. are vulnerable to tsunami damage. For many coastal communities, bridges serve as the only regional transportation lifeline and are critical for the mobility of people, goods, and post-event response. To ensure reliable mobility after extreme events, it is necessary to understand, model, and design for bridge response under tsunami loading. However, studies on wave-structure interaction are constrained by the financial cost of experiments and the computational cost of computational fluid dynamics (CFD) and fluid-structure interaction (FSI). In addition to their computational expense, e.g., three-dimensional simulations can take days to run on multi-core processors, CFD/FSI models are nonlinear and subject to a variety of modeling uncertainties and input assumptions. Moreover, the computational expense makes CFD/FSI impractical for “parametric problems”, like simulation-based design and optimization, fragility analysis, uncertainty propagation, etc., which require a large number (thousands) of simulations.



Research Project

Model reduction is desired, if not indispensable, for many parametric and/or computationally expensive applications. This research will explore machine learning algorithms designed to estimate the tsunami loading on bridges based on structural properties and flow conditions. Machine learning enables “reduced” models that represent the essence of the original fulldimensional numerical model. If provided enough data, the algorithms can infer physical assumptions and discover input (initial conditions) and output (bridge response) relationships, resulting in a smaller model with fewer, less expensive numerical equations. Because the “reduced model” is computationally inexpensive, it can replace the original simulation for parametric problems, resulting in optimization and statistical solutions that are currently not feasible. Moreover, if properly designed, machine learning architectures can retain the relevant physics, e.g., satisfying momentum and mass balance. A high performance GPU computing cluster at OSU will be utilized in order to perform model reduction on experimental and simulationbased data of tsunami loading on bridges.

ABOUT THE AUTHORS

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

ABOUT THE FUNDERS

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EXPECTED DATE OF COMPLETION

August 2021

FOR MORE INFORMATION

http://depts.washington.edu/pactrans/research/projects/pilot-study-learning-fluid-structure-interaction-via-machine-learning/

For questions contact PacTrans at pactrans@uw.edu | 206.685.6648 | www.pactrans.org
More Hall 112, Dept. of Civil & Environmental Engineering | University of Washington, Seattle, WA 98195-2700