Simulation-driven natural hazard risk assessment and risk-informed design through surrogate modelling applications

Alexandros A. Taflanidis
Associate Professor and Frank M Freimann Collegiate Chair in Structural Engineering
Department of Civil and Environmental Engineering and Earth Sciences
University of Notre Dame, IN, USA

Abstract:

Resilience to natural hazards is widely acknowledged as one of the most important challenges of the 21st century for the civil engineering community. Proper quantification of this resilience needs to consider different, potentially competing, metrics related to the life-cycle performance of infrastructure systems, and to fully leverage the vast intellectual resources that have been developed the past decade to better model/understand natural hazards and the risks they pose to our communities. Integral to this discussion is the quantification/assessment of risk. This seminar starts by presenting a versatile, probabilistic framework for facilitating these tasks (risk quantification/assessment) relying on stochastic simulation. Surrogate modelling principles are then introduced to alleviate computational burdens something necessary when high-fidelity models are adopted to describe the hazard or the structural response.

This risk quantification and metamodeling integration is demonstrated within two different topics (and hazards). The first one is multi-criteria, risk-informed design. Objectives that represent different attitudes towards risk (risk-neutral, risk averse) or different performance quantifications are adopted for formulating a multi-objective design problem, illustrated in this case for seismic retrofitting actions. For the associated optimization, to identify the Pareto-front of dominant solutions, kriging metamodeling is adopted, with the metamodel formulated to simultaneously support both the uncertainty propagation (calculation of risk integrals) and the design optimization. The second topic focuses on rapid risk assessment for hurricane risk to guide decisions of emergency response managers. Emphasis is placed here on development of real-time tools that are readily implementable within cyber-portals.

Brief Bio:

Dr. Alexandros Taflanidis is Associate Professor and the Frank M. Freimann Collegiate Chair in Structural Engineering in the Department of Civil and Environmental Engineering and Earth Sciences at the University of Notre Dame. He holds a concurrent position at the Department of Aerospace and Mechanical Engineering and he is also a Faculty Fellow at the Kellogg Institute for International Studies. He received his Bachelors (2002) and Masters (2003) in Civil Engineering from Aristotle University of Thessaloniki, Greece. He got his PhD in Civil Engineering with minor in Control and Dynamical Systems from the California Institute of Technology (2008). His research focuses on uncertainty quantification and uncertainty-conscious analysis/design, with main applications on natural hazard risk mitigation and sustainability/resilience of civil infrastructure systems. A special area of interest for his group is integration of soft-computing techniques in risk assessment/design. He also has a strong interest in engineering problems for the developing world and is the co-founder of Engineering2Empower, an organization training the next generation of global citizens while building a world where communities discover and cultivate their unique potential for resilience.