Multiscale and Multidimensional Quantification and Propagation of Manufacturing Induced Uncertainty

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ABSTRACT

Integrated Computational Materials Engineering (ICME) hinges on engineering microstructural features into the materials design process where the overarching goal is to search for materials with superior structure-level performance while systematically accounting for various sources of uncertainties, including those introduced by manufacturing processes. Quantification of manufacturing induced uncertainties is significantly challenging since they are multi-dimensional, spread across different length-scales, spatially correlated, and embody different characteristics (e.g., topological vs. property-related). In this talk, we address these challenges by presenting a non-intrusive computational approach for multiscale and multidimensional uncertainty quantification. We introduce the top-down sampling method that allows to model non-stationary and continuous (but not differentiable) spatial variations of uncertainty sources by creating nested random fields. We employ multi-response Gaussian random processes in top-down sampling and leverage sensitivity analyses and supervised learning to address the considerable computational costs of multiscale simulations. Examples with carbon fiber reinforced polymer (CFRP) composites will be used to illustrate the broader impact of the uncertainty quantification methods for reducing the production costs by guiding the manufacturing and quality control processes.

BIOGRAPHY

Wei Chen is the Wilson-Cook Chair Professor in Engineering Design at Northwestern University. Directing the Integrated DEsign Automation Laboratory (IDEAL- http://ideal.mech.northwestern.edu/), her current research involves issues such as simulation-based design under uncertainty, model validation, stochastic multiscale analysis and design, robust shape and topology optimization, multidisciplinary optimization, consumer choice modeling and enterprise-driven decision-based design. Dr. Chen received her Ph.D. from the Georgia Institute of Technology in 1995. She is currently serving as the Editor of the ASME Journal of Mechanical Design. She served as Chair and a member on the ASME Design Engineering Division (DED) Executive Committee (2009-2015) and was an elected Advisory Board member of the Design Society (2007-2013). She is an Associate Editor of Design Science, a review editor of Structural and Multidisciplinary Optimization, and served twice as an Associate Editor of the ASME Journal of Mechanical Design. In addition, she served as the Associate Editor of SIAM/ASA Journal on Uncertainty Quantification (JUQ) and the Department Editor for the IIE Transactions (2015-2018). Dr. Chen was the recipient of the 2015 ASME Design Automation Award 1996, NSF Faculty Early Career Award, the 1998 American Society of Mechanical Engineers (ASME) Pi Tau Sigma Gold Medal achievement award, the 2006 SAE Ralph R. Teetor Educational award. She is a Fellow of American Society of Mechanical Engineers (ASME) and an Associate Fellow of American Institute of Aeronautics and Astronautics (AIAA)