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Robust Design Optimization for Complex Systems Using Scientific Computation

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206 Furnas

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ABSTRACT

The design of complex physical systems requires accurate analysis of interactions among multiple components which are typically influenced by challenging uncertainty and nonlinear effects. Addressing these challenges calls for rigorous yet efficient tools in numerical optimization, stochastic modeling and high-performance computing. This talk demonstrates the synthesis of such tools to facilitate the design of complex engineering systems. First, I discuss the structural topology optimization which has emerged as a powerful computational tool in designing vast variety of high performance structures. In particular, I present a novel design under uncertainty approach where the effect of geometric uncertainty in the form of manufacturing tolerances is introduced in the topology optimization process. The effectiveness of this approach and the improved performance of risk-aware designs compared to ``usual'' deterministic designs is demonstrated via an illustrative example which mimics a 3D printing process. Next, I present a systematic framework for shape optimization of a wind turbine blade considering the uncertainty effects in the wind loads and material properties of the blade. Particularly, this framework combines a reduced order finite element model, aerodynamic simulation and gradient-based optimization which provides a computationally tractable design platform for such a complex engineering system. Throughout the talk I also discuss the computational aspects (i.e. efficiency and accuracy) of reduced order models in analysis and design and briefly present some of the recently developed numerical approaches including: 1) a novel quadrature rule for numerical integration on domains possibly with high dimensions and general geometries, 2) incorporation of multi-resolution finite element models for parametric stress-based topology optimization and 3) image-based deep learning for design space exploration. Finally, future research directions will be discussed.

BIO SKETCH

Vahid Keshavarzzadeh is currently a Postdoctoral Fellow in the Scientific Computing and Imaging Institute (SCI) at the University of Utah (Feb 2017-Present). Prior to joining SCI, he served as a Postdoctoral Research Associate in the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign (Nov 2014-Jan 2017). He received his Ph.D. in Structural Engineering (2014) and a M.Sc. in Electrical Engineering (2010) from the University of Southern California, and a M.Sc. in Structural Engineering (2007) and B.Sc. in Civil Engineering (2005) from Sharif University of Technology, Tehran, Iran. His research mainly focuses on design optimization and uncertainty quantification of complex (structural) systems. To that end, he also focuses on developing novel frameworks to address the computational and modeling challenges associated with design optimization of complex systems.

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