Parametric modeling and computational analysis of complex engineering structures

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Abstract:
For engineering systems that are challenging to study experimentally due to the large scale, high cost, or inaccessibility of the structures, computational simulation offers significant advantages for assessing the physical properties, structural mechanics, performance, and relevant system metrics before conducting experimental evaluations. Over the past few decades, computer-aided design (CAD) and engineering (CAE) methods have evolved significantly and provide many effective options for computational modeling but can be limited when investigating the design and critical features of many engineering systems and devices. As a result, many engineering sectors continue to rely on traditional design practices due to modeling and simulation constraints, often resulting in limited adaptability and innovation even as these industries move toward digital thread environments that benefit significantly from comprehensively integrated design, analysis, manufacturing, and operating procedures.

The presented research offers novel approaches to reimagining the engineering design process through interconnected computational modeling and analysis infrastructures that leverage parametric and algorithmic strategies. These methods are augmented by the fundamental premise of isogeometric analysis (IGA), which enables direct integration of design and analysis by incorporating the same representation of the exact geometry model for both design and analysis, eliminating the traditional meshing steps required by other simulation methods. Several industrial applications are presented to demonstrate the broad applicability of the proposed parametric and algorithmic modeling methods, including for renewable energy, biomedical, and aircraft systems. These strategies enable the development of novel design families or configurations that can be flexibly modified and adjusted to accommodate varying constraints or operating conditions and effectively optimized in conjunction with the developed modeling and simulation workflows.

Bio:
Emily Johnson is an Assistant Professor of Aerospace and Mechanical Engineering at the University of Notre Dame. Before starting at Notre Dame, she earned her Ph.D. in Mechanical Engineering and the Wind Energy Science, Engineering, and Policy program at Iowa State University in 2021. Dr. Johnson's primary research interests are in the areas of computational parametric modeling, analysis, and optimization, emphasizing engineering and mechanics problems with practical applications in numerous fields. Her current work is focused on the performance-based design of complex engineering structures, including energy, biomedical, and aerospace applications.

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1310 Yeh Student Center