MECHANICAL & MATERIAL COLLOQUIUM

Toward Robust Architected Materials: Fast Sensitivity and Uncertainty Quantification

by Dr. David Restrepo (University of Texas)

This presentation introduces a novel computational framework for accurately evaluating the sensitivity of material parameters and their variability in the mechanical response of architected materials. The approach integrates the Finite Element Method (FEM) with the Hypercomplex Automatic Differentiation (HYPAD) technique. The resulting HYPAD–FEM framework enables the efficient computation of arbitrary–order sensitivities with respect to geometric, material, and loading parameters, without the numerical instabilities or implementation burdens associated with traditional differentiation methods. These capabilities provide deeper insight into how key design parameters influence material response and form the basis for a new moment-based, fast uncertainty quantification (UQ) method. The proposed fast-UQ approach approximates probabilistic moments of simulation outputs using a single high-fidelity finite element simulation, while also delivering Sobol indices that quantify the importance of individual input parameters and their interactions. Preliminary results demonstrate that this method reproduces probability density functions with accuracy comparable to Monte Carlo sampling and polynomial chaos expansions—yet at only a fraction of the computational cost.

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Dr. Restrepo is an Associate Professor and Endowed Faculty Professor in Mechanical Engineering at the Klesse College of Engineering & Integrated Design (KCEID) at the University of Texas at San Antonio. He was a Postdoctoral Fellow at Northwestern University in the Department of Mechanical Engineering. He received his Ph.D. in Engineering from Purdue University in 2015. Dr. Restrepo's research focuses on advancing the development of new materials with exceptional properties and functionalities. To achieve this goal, his research thrust areas encompass architected materials, additive manufacturing, and bioinspired design. His research approach combines computational simulations, theoretical analysis, fabrication, and experimental testing to bridge the gap between theoretical concepts and practical applications. Dr. Restrepo has received several awards for his research, including the prestigious CAREER award from the National Science Foundation. His sponsored research activities include grants from the National Science Foundation, the Navy Research Office, the Army Research Office, and the Air Force.

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For questions, comments and suggestions, contact Colloquium Organizers Dr. Saja AL Rifai (salrifai@fiu.edu) or Dr. Jiuhua Chen (chenj@fiu.edu)