Structural Engineering Seminar Series

CEE595S

Topology Optimization with Multiple Materials, Multiple Constraints, and Multiple Load Cases

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Abstract: Topology optimization is a practical tool that allows for improved structural designs. However, most work in this field has been restricted to single material with linear material behavior, limited volume constraint settings, and a single load case. To address these issues, we propose an efficient multi-material topology optimization formulation considering material nonlinearity. The proposed formulation handles an arbitrary number of candidate materials with flexible material properties, features freely specified material layers, and includes a generalized volume constraint setting. To efficiently handle such arbitrary volume constraints, we derive a novel design update scheme that performs robust updates of the design variables associated with each volume constraint independently. We show that the update of design variables in each volume constraint only depends on the corresponding Lagrange multiplier. To obtain designs under many load cases, we also present a randomized approach that efficiently optimizes structures under hundreds of load cases. This approach only uses 5 or 6 stochastic sample load cases, instead of hundreds, to obtain similar optimized designs (for both continuum and truss topology optimization). Through examples using combinations of various materials, we demonstrate that the proposed topology optimization frameworks with the aforementioned update scheme and randomized algorithm lead to design tools that not only find the optimal topology but also select the proper type and amount of material, with drastically reduced computational cost.

Bio: Dr. Shelly Zhang is an Assistant Professor at the Civil and Environmental Engineering Department in the University of Illinois at Urbana Champaign. Dr. Zhang received her doctoral degree from Georgia Tech in 2018 with the best Ph.D. thesis award, and her bachelor's and master's degrees in structural engineering from the University of Illinois at Urbana Champaign. Her research focuses on exploring topology optimization, stochastic programming, machine learning, and additive manufacturing to develop resilient, smart, sustainable, and innovative engineering infrastructure and materials for applications at different scales, from as large as high-rise buildings to as small as material microstructures.

Monday, January 28th, 4:00-5:00pm
1310 Yeh Student Center