Strategies to Incorporate Mechanics and Manufacturability in Topology Optimization

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Abstract:

Recent decades have seen a rapid development in all manufacturing technologies, including additive manufacturing (AM). This has raised the need for design methods that can leverage the new, increasingly complex fabrication possibilities. Topology optimization has the potential to generate new high-performing design solutions since it is a free-form design method that does not require a pre-conceived notion of the final layout. It uses computational mechanics and optimization tools to generate improved designs. For in-operando designs to perform as predicted, the used model must capture the material behavior. Additionally, the planned manufacturing process might induce both material characteristics and design limitations that should be considered as the design is generated. This talk focuses on the need for identifying and incorporating both behavioral and manufacturing aspects within the design process. Different strategies for integration within topology optimization will be discussed. This includes consideration of both material and geometric nonlinearities through the example of designing a low-weight Bulk Metallic Glass (BMG) with maximized energy absorption. The energy absorption is in this work simplified as the area under the static stress-strain and an improved performance is experimentally shown by comparison to a conventional honeycomb topology. The incorporation of manufacturing induced material characteristics is illustrated through tailoring design to material extrusion-based AM. In material extrusion, a nozzle moves across a build plate and deposits a material bead on a 2D slice of the design. These processes typically induce some degree of anisotropy through weak(er) bonding between adjacent beads. Finally, a new design framework is introduced in which interactive participation of the design engineer is enabled to resolve more complex mechanic phenomena.

Bio:

Josephine Carstensen is the Gilbert W. Winslow Career Development (Assistant) Professor in the Department Civil and Environment Engineering (CEE) at MIT. She leads the Carstensen Group, conducting research that revolves around the engineering question of “how we design the structures of the future?” Her work spans from development of computational design frameworks for various structural types and design scenarios over experimental investigations that are used to inform necessary algorithmic considerations.

Dr. Carstensen has received awards for both research and teaching, including the National Science Foundation CAREER award and CEE Maseeh Award for Excellence in Teaching. She joined the MIT CEE faculty in 2019 after two years as a lecturer at MIT, jointly appointed in CEE and Architecture. She received her PhD from Johns Hopkins University in 2017 and holds a B.Sc. and a M.Sc. from the Technical University of Denmark.

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