Virtual Element Method (VEM)-Based Topology Optimization: A General Framework

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We present a Virtual Element Method (VEM)-based topology optimization framework using polyhedral elements, which allows for easy handling of non-Cartesian design domains in three dimensions. We take full advantage of the VEM properties by creating a unified approach in which the VEM is employed in both the structural and the optimization phases of the framework. In the structural problem, the VEM is adopted to solve the three-dimensional elasticity equation. Compared to the finite element method (FEM), the VEM does not require numerical integration and is less sensitive to degenerated elements (e.g. ones with skinny faces or small edges). In the optimization problem, we introduce a continuous approximation of material densities using VEM basis functions. As compared to the standard element-wise constant one, the continuous approximation enriches geometrical representations of structural topologies. Through two numerical examples with exact solutions, we verify the convergence and accuracy of both the VEM approximations of the displacement and material density fields. We also present several design examples involving non-Cartesian domains, demonstrating the main features of the proposed VEM-based topology optimization framework.

Biography

Mr. Heng Chi is a PhD candidate in the School of Civil and Environmental Engineering at Georgia Institute of Technology. His research interests are on developing novel computational methods for various applications (e.g. soft materials, micro-mechanics and topology optimization), as well as exploring the design and realization of multi-functional material systems using topology optimization and advanced manufacturing. He is the winner of the 2017 Robert J. Melosh Medal for the Best Student Paper on Finite Element Analysis. Mr. Heng Chi received his B.E. degree in Civil Engineering from Tianjin University in 2011, and his M.S. degree in Civil Engineering from the University of Illinois at Urbana-Champaign in 2014.