Topology Optimization using Polytopes

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In the past few decades, topology optimization methods have been applied to a wide range of practical applications. In the literature, typically a uniform grid of linear quads/bricks is used for topology optimization problems. Numerical anomalies, such as checkerboard pattern and one-node connections arise out of such formulations. Constraints in the geometrical features of spatial discretization can result in mesh dependent designs [2]. Polygonal elements, which do not suffer from such numerical anomalies, have been investigated in the past in two-dimensional topology optimization [1], [2]. In the current work, we propose the use of polyhedral meshes to address the geometric features of the domain discretization. Polyhedral meshes provide a greater flexibility in discretizing complex domains. Moreover, techniques such as mesh refinement and coarsening produce elements which are inherently polyhedral. Typically, in order to solve the state equation on polyhedral meshes, the computation of global stiffness matrix would require conducting numerical integration in physical coordinates and dealing with each polyhedral element individually. In order to achieve numerical accuracy, a very high order quadrature is required which is computationally expensive. In the current work, we demonstrate the effectiveness of our Virtual Element Method (VEM) based approach for three-dimensional linear elastic topology optimization. The VEM is considered as the next evolutionary stage of the Mimetic Finite Difference (MFD) methods. In VEM approach, the stiffness matrix computation reduces to the evaluation of matrices which involve only surface integral terms, in contrast to the volume integrals encountered in conventional FEM, thus reducing the computational cost. The features of the current approach are demonstrated using various numerical examples for compliance minimization problem.

References

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