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Spectral Finite Elements for High-resolution Topology Optimization

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The h-version finite element method (h-version FEM) has been predominantly used in topology optimization to date since it is more suitable for traditional element-based topology optimization strategies. Spectral finite element methods or high-order finite element methods have been developed and well documented in the literature. Recently, the p-version finite element method (p-version FEM), one of the spectral finite element methods, has gained increasing popularity for analysis especially among front-end CAE packages where topology optimization is also used increasingly. In this work, we investigate the use of p-version FEM for topology optimization, and propose a topology optimization method that can take the advantage of the p-version FEM. Unlike the traditional element-based topology optimization method where a density design variable is assigned to each finite element, our approach separates density variables and finite elements so that the resolution of the density field, which defines the structure, can be higher than the finite element mesh. Thus, we can take full advantage of the higher accuracy that p-elements offer and overcome the disadvantage of coarse meshes usually used with p-version FEM. We demonstrate through examples that, with suitable techniques, topology optimization using p-version FEM enables achieving high resolution results with reasonable computational cost.

Keywords: p-version FEM, multi-resolution, density method, spectral finite elements