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A Multi-Material Topology Optimization Algorithm for Continuum (and other) Structures

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Abstract

A particularly promising new aspect of 3D polymer printers, such as the PolyJet line by Stratasys, is the ability to print components composed of multiple materials, in process, without the need to swap out print heads or feedstock. With this technology in mind, a new topology optimization algorithm is proposed for the design of structures composed of multiple materials. The goal, put simply, is to determine whether material exists at every point in space within the design domain and, if so, which material phase, selected from a library of options, is to exist at that point. The proposed approach is built on Heaviside Projection Method where independent design variables are projected onto finite element space to determine topology. The key feature of the proposed approach is that multiple projections occur from each point in space, and unlike past works controlling the length scale of two-phases, these projections are superposed to determine the material phase located within each finite element. The algorithm is presented in the context of standard SIMP-based material distribution methods and is solved using the Method of Moving Asymptotes. Several design examples are considered, including the design of compliant mechanisms, and experimental results are demonstrated for select problems. Extensions to truss and frame topology optimization are also discussed.