Single and Multi-Component Topology Optimization for Additive Manufacturing

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Abstract

Additive manufacturing (AM) is an innovative technology actively pursued in many industries to produce high-complexity components. With the increased design freedom from AM when compared to traditional manufacturing methods, improved performance can be achieved if parts are redesigned appropriately. Topology optimization (TO) is a design generation tool that determines an optimized material distribution within a design space to maximize a given performance metric. While AM is perfectly suited to produce the complex designs generated with TO, manual interpretation of optimized results is needed to ensure components can be easily manufactured. This can be achieved using design for AM (DfAM) principles, which aim to reduce cost and ensure manufacturability of AM components. By integrating DfAM techniques into the TO process, highly optimized and cost-effective designs can be tailored specifically for AM, without the need for manual interpretation.

This work presents three approaches for integrating DfAM considerations into topology optimization. First, the fabrication cost of a single component is reduced by optimizing the part geometry and build orientation to minimize support structure volume requirements [1]. Next, a void region restriction constraint is incorporated to avoid infeasible designs with internal voids that result in unremovable support material or powder granules [2]. Finally, the cost of an assembly is minimized through a multi-objective problem statement that includes the number of joints, volume of support structure, and surface area. This part consolidation (PC) problem is solved using a multi-layered design space approach that allows for convergence towards a single or multiple component design [3].

This paper reviews the fundamental theory for calculation of support structure, surface area, and internal void regions. The TO methodology for build orientation optimization, void region restriction, and multi-layered PC is also presented. These approaches are verified on several 3D example problems, achieving high quality results with improved manufacturability and reduced cost when compared to the baseline TO problem statement.

References

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