Support Structure Constrained Topology Optimization for Additive Manufacturing

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ABSTRACT

Background: With recent advances in additive manufacturing (AM) and topology optimization (TO), there is a significant interest in integrating the two fields [1]. Although TO and AM have flourished independent of each other, there is significant interest today in integrating them for two primary reasons: (1) Designs stemming from TO are geometrically complex, and therefore hard to manufacture using traditional processes, but can often be additively manufactured. (2) The cost of fabricating parts through AM is directly proportional to the amount of material used, and material usage can be easily reduced through TO.

Problem Statement: While these and other characteristics make TO and AM ideally suited for each other, there are several challenges that must be addressed. One of the challenges is that a topologically optimized design will typically need extraneous support structures to avoid ‘drooping’, and ‘burning’ during additive manufacturing. Support structures not only increase fabrication cost, they lead to significant post-fabrication, i.e., clean-up, costs [2].

Contribution: In this paper, we propose a methodology for limiting the amount of support structures during TO. Towards this end, the concept of ‘support structure sensitivity’ is introduced. This is then combined with classic compliance sensitivity to result in a TO framework that minimizes compliance, subject to support structure constraints. The robustness and efficiency of the proposed method is demonstrated through numerical experiments, and validated through AM.

Results: In the attached figure, on the left is a mount bracket subject to a structural load; the objective is to minimize the compliance with a target volume fraction of 0.5. In the middle is the optimal topology without support structure constraints. On the right is the optimal topology when additional support structure constraints were imposed. The amount of support structure was reduced by 80%, while the compliance increased by 20% (compared to the unconstrained design).

References