Automatic Orientation Initialization in Simultaneous Topology and Build Orientation Optimization for Additive Manufacturing

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Additive manufacturing enables the production of highly complex structures by printing in a layer-by-layer method and can help achieve lightweight structures in the aerospace industry. However, parts must be completely redesigned for additive manufacturing to leverage the improved design freedom and to account for its unique cost driving factors. Simultaneous topology and build orientation optimization techniques aim to achieve this goal by generating structural designs that maximize stiffness and minimize support structure requirements for the selected orientation. Current approaches in literature optimize build orientation using gradient-based methods, whose effectiveness is severely limited based on the selected initial orientation. This work proposes an effective approach for automatically initializing build orientation design variables through a coarse search of the design space, eliminating the need to rerun the optimization with a series of initial orientations to achieve an acceptable solution. In addition, a methodology for simultaneous topology and build orientation optimization is presented, using a multi-objective problem statement that minimizes the sum of structural compliance and overhanging surface area. The proposed method is implemented in a custom code and demonstrated on the design of an airplane bearing bracket from the 2016 GrabCAD community challenge. The effectiveness of the automatic build orientation initialization technique is validated by comparing the optimized result to a set of build and topology optimization results with different initial orientations, alongside topology optimization results for several fixed orientations. This study found that the automatic initialization procedure achieved the best orientation obtained from the manual orientation initializations with a similar objective function value.