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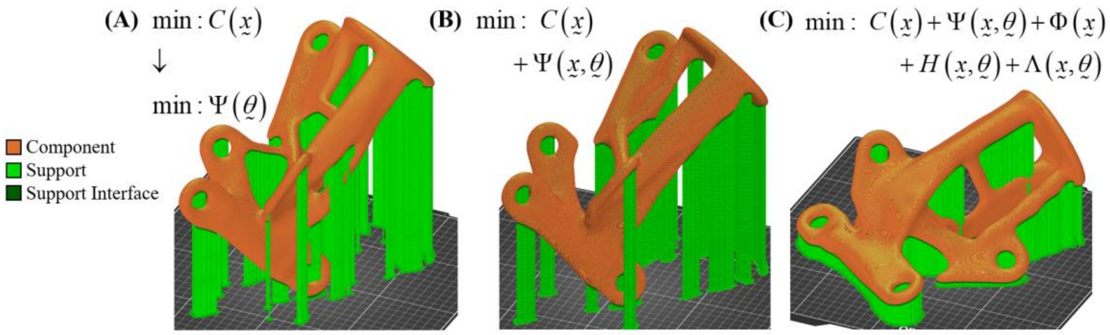
Additive Manufacturing Cost Minimization using Multi-Objective Topology and Build Orientation Optimization

Il Yong Kim[1*], Luke Crispo[1]
[1] Queen's University, Kingston, Ontario, K7L 3N6, Canada
E-mail: kimiy@queensu.ca

Additive manufacturing and topology optimization enable the design and fabrication of highly complex components with the potential for significant weight savings in the aerospace and automotive industries. Recent research has proposed topology and build orientation optimization approaches for additive manufacturing [1], which has unique design constraints and cost-driving factors. However, existing methods consider only one or two physical properties during optimization, and therefore can only achieve limited reductions in printing time and material use.

This work develops a novel topology and build orientation optimization approach for additive manufacturing, capable of simultaneously considering structural performance and additive manufacturing cost. A comprehensive cost metric uses four physical properties to model cost during optimization: build height, surface area, overhang area, and support structure volume. These objectives are derived as differentiable functions and sensitivity analysis is completed to enable efficient gradient-based optimization.

The developed method is verified using a tensegrity joint numerical test problem, showing that the multi-objective approach generates designs that cannot be obtained with existing methods. Slicer software is used to measure material use, printing time, and post-processing metrics, demonstrating real-world cost savings of the optimized designs. By considering all cost objectives simultaneously, the proposed method reduces material use by 26% and print time by 33% compared to a sequential topology and build orientation optimization considering only overhang area, as shown in Figure 1.



Print Time	32 hr. 12 min.	27 hr. 58 min.	-13%	21 hr. 28 min.	-33%
Total Filament Use	799 g	719 g	-10%	588 g	-26%
Compliance	29.1 J	29.8 J	+2%	29.7 J	+2%

Figure 1: Reduction in cost metrics through topology and build orientation optimization

Key Words: *design for additive manufacturing, topology optimization, build orientation optimization, support structure, overhang*

REFERENCES

[1] L. Crispo and I.Y. Kim, Topology and build orientation optimization for additive manufacturing considering build height and overhang area, Structural and Multidisciplinary Optimization, 67 (6), 1-36, 2024.