Topology optimization for additive manufacturing using isogeometric analysis

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ABSTRACT

Additive manufacturing (AM) can fabricate geometric forms that are impossible to produce with traditional manufacturing. It is also capable of producing parts of multiple graded materials. However, current CAD technologies are a bottleneck in realising the full potential of AM.

Topology optimization (TO) is one of the technologies that can be used to exploit the freedom of design that AM brings [1]. However, there are two major concerns when combining TO and AM. The first is that the representations used in TO based on finite element modelling (FEM) result in rough structures that have to be remodelled as smooth surfaces typically using costly manual labour. The second is that the manufacturing constraints of AM, though far fewer than traditional manufacturing technologies, still need to be taken into account during the optimization in order to ensure the final object is in fact printable. For example, depending on the AM technology and the material that are used, there is a specified minimal wall thickness that must be satisfied to avoid weak structures. The need for internal, non-removable support structures is also something that is desirable to avoid, and can be achieved by by specifying the gradient of internal void ceilings.

In this work we explore the use of isogeometric analysis (IGA) [2] for performing TO that conforms to the constraints of AM. IGA was originally established as an approach to unifying the design and simulation stages of product development by providing a common representation based on splines. Trivariate spline representations have also been shown to be a good match for AM [3] in terms of simulation and non-trivial material representation. We utilize these same representations to perform topology optimization, and discuss the pros and cons of this approach.

REFERENCES

[1] Brackett, D., Ashcroft, I., & Hague, R. (2011). Topology optimization for additive manufacturing. In *Proceedings of the solid freeform fabrication symposium*, Austin, TX (Vol. 1, pp. 348-362). S.

[2] Hughes, T. J., Cottrell, J. A., & Bazilevs, Y. (2005). Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement. *Computer methods in applied mechanics and engineering*, 194(39-41), 4135-4195.

[3] Dokken, T., Skytt, V., & Barrowclough, O. (2018). Trivariate spline representations for computer aided design and additive manufacturing. *Computers & Mathematics with Applications* (in press).