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Reducing overhangs in additive manufacturing with Shape and Topology optimization

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One main goal of topology optimization is to find an optimal distribution of multiple materials in a design domain in such away that it can withstand internal and external loads applied on the structure. Additive manufacturing techniques like 3D-printing are able to produce complex structures and topologies. To guarantee constructability overhangs need either support structures or should be avoided in total. Using a phase field approach we include this restriction, by studying a control problem minimizing the weighted sum of the Ginzburg-Landau energy with the mean compliances of the whole structure and of each individual layer. To this end, we introduce multiple linear elasticity equations as state equations describing the displacement of the structure to the applied loads. To solve this problem numerically, the VMPT (Variable Metric Projection Type) method is presented and applied. Finally, we perform numerical experiments on multiple examples. The impact of model parameters on the shape and topology is discussed. Furthermore the enormous speed up with the VMPT method using variable metrics including second order information is presented.

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