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Improving stability and robustness of algorithms for gradient-based topology optimization

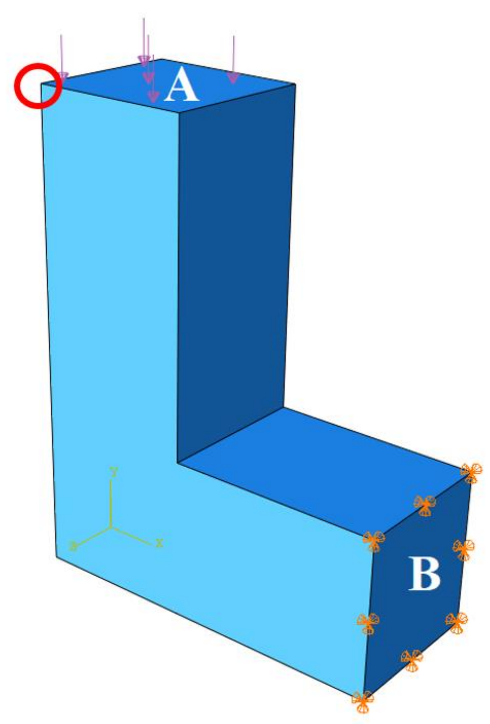
Motivation

Structural optimization is widely used during development of new products in automotive, aerospace and manufacturing industries resulting substantial economical benefits. High complexity of underlying theory causes inexperienced design engineers to encounter several issues while setting up an optimization problem.

Minimizing volume subject to displacement constraints

In topology optimization, volume minimization subject to displacement constraint is simple yet problematic optimization setup. Ill-posed optimization setups tend to yield structures with zero-volumes, severely violating the displacement constraint. This thesis tries to interpret such issues in aforementioned settings, and attempts to rectify the issues by suggesting two strategies. First strategy modifies the objective function, by adding an auxiliary strain energy term in volume objective. The second strategy modifies the displacement constraint, by applying the displacement constraint on entire model instead of particular locations.

Illustrative example of ill-posed optimization setup:



Volume minimization subject to single displacement constraint at highlighted node

Conclusion

Modification of objective function helps stabilizing the unstable optimization setup. Application of displacement constraint on entire finite element model prevents structures with zero volumes.

Ill-posed optimization setups involving volume minimization subject to displacement constraints are said to be effectively converted into equivalent well-posed problems.

Supervision

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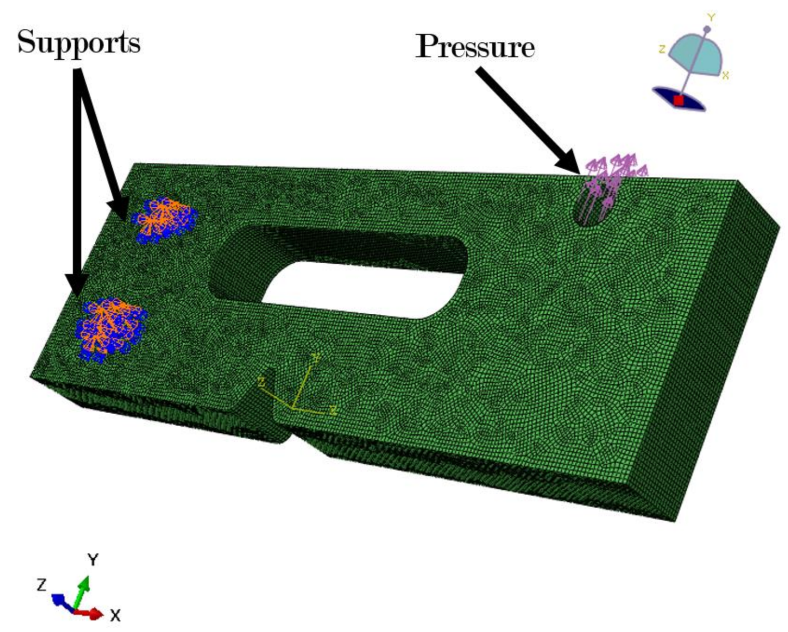
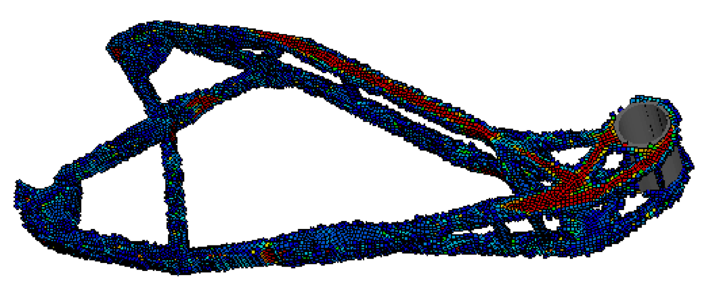
Illustrative Examples

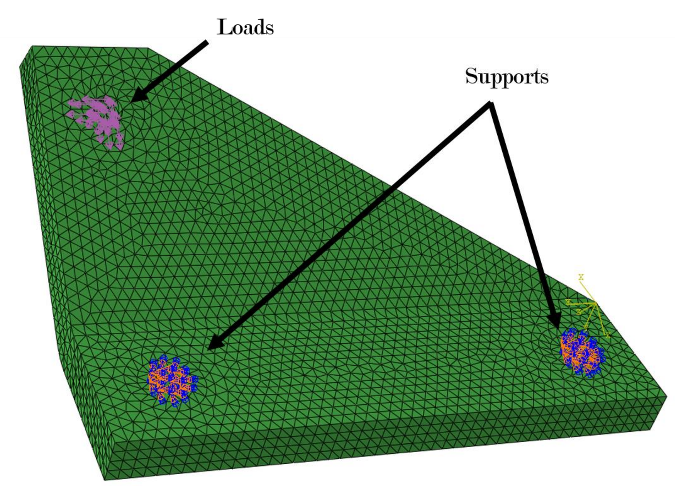
Volume minimization setups and final results:



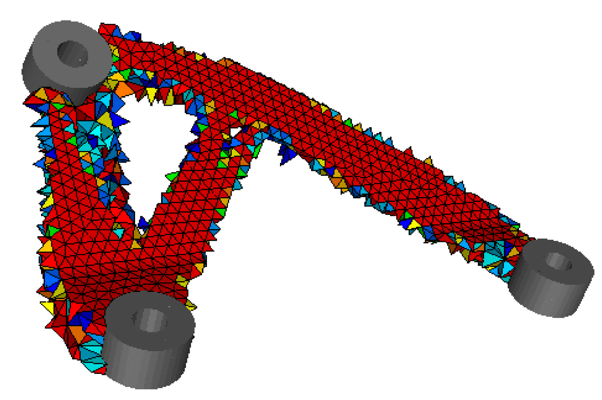
Aircraft component



Optimized topology,
Final volume= 9%



Compressor component



Optimized topology,
Final volume= 19%

Literature

Bendsøe, M. P., Sigmund O.: *Topology Optimization*. Springer Berlin Heidelberg, 2011.

Bendsøe, M. P.: Optimal shape design as a material distribution problem. In: *Structural Optimization* 1 (1989), dec, No. 4, p. 193–202

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