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Structural Optimization with Interior Point Methods

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Abstract
We discuss challenges related to solving real world problems in structural optimization. Such problems arise for example in layout optimization of tall buildings, long bridges or large spanning roofs. We propose to solve such problems with a highly specialized primal-dual interior point method.

The underlying mathematical models rely on the so-called ground structure approach. The design domain uses nodes and potential interconnecting bars. In the simplest case the ultimate design objective is to determine the cross-sectional areas of the bars by minimizing their total volume. Such formulation leads to a very large scale linear optimization problem. When additionally a global stability of the truss structure is taken into account, the problem involves nonlinear constraints and semidefinite constraints (in a form of linear matrix inequalites). The latter formulation leads to a large scale semidefinite optimization problem.

Both the linear and the semidefinite optimization formulations of these problems challenge the existing optimization software. The key difficulty being the size of resulting problems. Interior point methods are well suited to face such a challenge as they excel on large scale problems.

We discuss the computational aspects of a highly specialized interior point method tuned to structural optimization problems. We demonstrate that a carefully crafted method is able to solve problems which defy any standard commercial optimization solvers. We provide examples of real world engineering design problems which can now be successfully tackled.