11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

An efficient second-order SQP method for structural topology optimization

Susana Rojas-Labanda[1], Mathias Stolpe[1]

[1]Technical University of Denmark, Denmark

Abstract

Topology optimization based on density approaches and material interpolation schemes such as Solid Isotropic Material Interpolation (SIMP) result in non-convex nonlinearly constrained optimization problems. These problems are commonly solved using first-order structural optimization solvers such as the Method of Moving Asymptotes (MMA). Nevertheless, other general nonlinear methods can be applied. Sequential Quadratic Programming (SQP) methods, together with primal-dual interior-point solvers, are currently the state-of-the-art in second-order nonlinear solvers.

We propose a special-purpose SQP method for minimum compliance problems based on the general algorithm explained in [1]. It contains two phases to produce fast local convergence. First, an inequality constrained convex quadratic sub-problem is solved to estimate the set of active constraints, i.e. the working set. Then, an equality constrained quadratic sub-problem is solved with that working set. Both phases use exact second-order information. However, it is well known that the Hessian of compliance is dense, computationally expensive and for some designs, indefinite. In order to overcome these issues, a positive definite approximation of the Hessian is defined based on the exact Hessian. Moreover, the sub-problems are reformulated based on the specific characteristics of the problem to significantly improve the efficiency of the solver.

The performance of our SQP method is compared with the globally convergent version of MMA and with the two general-purposes solvers SNOPT and IPOPT, using a test set of 225 medium-sized topology optimization problem instances. Performance profiles confirm that use of the exact Hessian is decisive to produce optimal designs. Our SQP obtains more accurate design and more efficiently than classical first-order structural optimization solvers. Finally, the results show the great robustness of our SQP method.

References

[1] J. Morales, J. Nocedal, Y. Wu, A sequential quadratic programming algorithm with an additional equality constrained phase. Journal of Numerical Analysis, 35(2), 553 - 579, 2010.