Comparison of Sequential Approximation Optimization (SAO) Methods for Structural and Topology optimization

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ABSTRACT

In recent years, dual optimization methods based on sequential approximation optimization (SAO) methods have gained popularity when solving topology optimization problems [1, 2]. The main steps involved in the SAO methods are as follows: (a) Sub-problem: starting with a feasible design point, generate a convex and separable approximation of the primal objective function and constraints. (b) Dual problem: compute the dual of the sub-problem. Since the Lagrangian of the sub-problem is strictly convex, there is not duality gap. (c) Solve the unconstrained dual sub-problem using appropriate optimization methods. (d) Update the design point. The SAO methods are well suited for structural optimization problems where number of design variable far exceeds the number of constraints and, thus, working in dual spaces results in computational efficiency.

When using SAO methods, the quality of the approximations to the primal objective function and constraints determines the accuracy and efficiency of the scheme. The approximations are usually constructed using truncated Taylor series expansion with different intervening variables. The well-known methods – method of moving asymptotes (MMA) [3, 4] and convex linearization (CONLIN) [5] – use reciprocal-like intervening variables. Second order Taylor series expansion based on exponential intervening variables may result in equally efficient dual SAO algorithms, such as quadratic family [6]. To further improve the approximations, multi-point enhancement is adopted, such as two-point exponential algorithm [7] and two-point adaptive nonlinear approximation [8, 9].

The MMA is the mostly used SAO method for solving structural/topology optimization problems. However, it usually suffers from oscillation problem for its heuristic asymptotes update scheme. In order to overcome this drawback, a new two-point gradient-based method of moving asymptotes (TGMMA) is proposed by using the sensitivities of both of the current and previous point to enhance the MMA approximation. The method is based on two point exponential approximation method proposed by Fadel et al [7]. Numerical tests are carried out to study the effectiveness of the proposed scheme. Several approximation methods are also compared to show the effectiveness of the new method. It is shown that the TGMMA algorithm leads to fast convergence for minimum compliance problem and gives good results for compliant mechanisms.

References

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