

Title: “A Nonlinear Semidefinite Programming Algorithm for Structural Optimization”

Nonlinear Semidefinite Programming (SDP) deals with the minimization of an objective function with semidefinite constraints on nonlinear symmetric matrix-valued functions. Here we also include standard nonlinear equality and/or inequality constraints. SDP has a crucial importance for structural optimization, in problems involving eigenvalues. This is the case when considering constraints on the natural frequencies or imposing global stability.

The present formulation is based in the FAIPA-SDP, “ Feasible Arc Interior Point Algorithm for SDP”, an interior point algorithm that solves Karush-Kuhn-Tucker condition for SDP employing Newton like iterations, [1] and is also a generalization of the FAIPA, for classical nonlinear constrained optimization, [2]. It generates a descent sequence of points at the interior of the feasible set, defined by the classic and the semidefinite inequality constraints. The algorithm performs Newton-like iterations to solve the first order Karush-Kuhn-Tucker optimality conditions for the SDP problem. At each of the iterations, three linear systems with the same coefficient matrix must be solved. The first one generates a descent direction of the cost function. In the second linear system, a precisely defined perturbation in the left hand side is done and, as a consequence, a descent feasible direction is obtained. The third system computes an estimate of constraint’s curvature in order to get a feasible descent arc. An inexact line search along this arc is then performed, to ensure that the new iterate is interior and the objective is lower.

Structural analysis is usually carried out with the standard finite element method, working with symmetric matrices, presenting a particular structure, to define both the stiffness and the mass matrices. The present SDP algorithm takes advantage of the structure of these matrices with a large improvement of the computational efficiency.

Some numerical tests are described, as well as applications in structural optimization problems employing a mathematical model based on semidefinite programming. The results suggest efficiency and high robustness of the proposed method.

[1] Aroztegui, M. “Numerical Techniques for Semidefinite Programming and Applications in Structural Optimization”, Dr. Sci. Thesis, COPPE, UFRJ, Brazil, 2010,(in Portuguese).

[2] Herskovits J . A Feasible Directions Interior Point Technique For Nonlinear Optimization.. JOTA Journal of Optimization Theory and Applications, Londres, v. 99, n. 1, p. 121-146, 1998.