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Globally Convergent Sequential Linear Programming for Multi-Material Topology Optimization Using Ordered Solid Isotropic Material with Penalization Interpolation

Authors : Darwin Castillo Huamaní, Francisco A. M. Gomes

Abstract : The aim of the multi-material topology optimization (MTO) is to obtain the optimal topology of structures composed by many materials, according to a given set of constraints and cost criteria. In this work, we seek the optimal distribution of materials in a domain, such that the flexibility of the structure is minimized, under certain boundary conditions and the intervention of external forces. In the case we have only one material, each point of the discretized domain is represented by two values from a function, where the value of the function is 1 if the element belongs to the structure or 0 if the element is empty. A common way to avoid the high computational cost of solving integer variable optimization problems is to adopt the Solid Isotropic Material with Penalization (SIMP) method. This method relies on the continuous interpolation function, power function, where the base variable represents a pseudo density at each point of domain. For proper exponent values, the SIMP method reduces intermediate densities, since values other than 0 or 1 usually does not have a physical meaning for the problem. Several extension of the SIMP method were proposed for the multi-material case. The one that we explore here is the ordered SIMP method, that has the advantage of not being based on the addition of variables to represent material selection, so the computational cost is independent of the number of materials considered. Although the number of variables is not increased by this algorithm, the optimization subproblems that are generated at each iteration cannot be solved by methods that rely on second derivatives, due to the cost of calculating the second derivatives. To overcome this, we apply a globally convergent version of the sequential linear programming method, which solves a linear approximation sequence of optimization problems.

Keywords : globally convergence, multi-material design ordered simp, sequential linear programming, topology optimization
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