A dual-mesh approach for adaptively refined stress constrained topology optimization

Daniel A. White*, Youngsoo Choi† and Jun Kudo†

* Lawrence Livermore National Laboratory
Livermore, CA 94550 USA
e-mail: white37@llnl.gov

† Lawrence Livermore National Laboratory
Livermore, CA 94550 USA
e-mail: choi15@llnl.gov

† Lawrence Livermore National Laboratory
Livermore, CA 94550 USA
e-mail: kudo4@llnl.gov

ABSTRACT

The advancement of manufacturing methods is creating a great need for commensurate advancement of computational design methods and software. One such computational design method is topology optimization, in this method the designer specifies high level objectives and constraints and the optimal material distribution is determined via an iterative nonlinear optimization algorithm. Within each iteration the equations of linear elasticity are solved via the finite element method. The most common topology optimization problem consists of minimizing the compliance subject to a constraint on the mass, and a popular algorithm for solving this problem is the solid isotropic material with penalization (SIMP) method [1]. This method employs a one-to-one correspondence between the elements of the finite element mesh and the material distribution, i.e. the optimization decision variables are the relative density of material in each element.

Many real-world design problems are concerned with not just minimization of compliance, but also satisfying a constraint on the stress [2]. It is well known that the stress field can exhibit singularities and accurate resolution of theses singularities requires a highly refined finite element mesh. Adaptive mesh refinement has successfully been used to resolve the singularities in a computationally efficient manner [3]. But this poses a problem for optimization, because when the computational mesh is refined the optimization decision variables are completely redefined, and the optimization process must somehow be restarted with a new set of decision variables. Our solution is to employ dual meshes, a design mesh for the finite element representation of the material distribution, and an analysis mesh for the computation of displacement, strain, etc. On the design mesh the material distribution is given by higher order Bernstein polynomials. The analysis mesh can be adaptively refined without affecting the decision variables. Results will be presented for this dual mesh approach, demonstrating that this approach is effective for stress-constrained topology optimization problems.

REFERENCES

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