A flexible approach for multi layer shape optimization

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ABSTRACT

A new method for the optimal distribution of finitely many materials in a design space is discussed. Typically, topology optimization (e.g. SIMP based) methods turn out very efficient for this purpose. For certain applications it is important however that each of the material phases remains connected throughout optimization. Unfortunately a constraint of this type can hardly be integrated in any known topology optimization model.

On the other hand in the framework of shape optimization methods connectivity is naturally maintained. However, most parametric shape optimization approaches are concerned with optimization of outer boundaries rather than interfaces between different materials layers. Moreover, depending on the complexity of the design domain, only conservative design changes are feasible.

We present a new parametric shape optimization approach in which deformations of a reference domain are considered as design variables. The well definedness of the design domain is guaranteed by a set of Lipschitz type constraints with a single Lipschitz constant. It turns out that the new type of constraints do not only preserve the topology of the reference domain, but also regularize the shape optimization problem. Moreover, choosing the Lipschitz constant close to 1, almost arbitrary changes of the boundaries as well as interfaces are allowed.

The new approach is not limited to the design of the outer boundary of a body, but can also be used to optimize interfaces between different materials. Typical examples are the optimization of multi-layer bodies, or identification problems, by which one seeks unknown positions and shapes of inclusions in a matrix.

Based on static as well as transient linear elasticity problems, a rigorous mathematical formulation of the optimization problem in appropriate function spaces is introduced. A theorem is established which ensures existence of solutions to the problem for a wide range of objectives, including compliance and tracking type functionals. Furthermore, a discretization scheme along with a convergence statement is shown.

The presentation will conclude with different numerical examples, including compliance optimization problems as well as identification problems in the framework of which position and shape of inclusions in a a matrix material are identified using a transient boundary tracking functional.