Computational design of structures and materials: from micro-scale to macro-scale

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Abstract

Quite recently, considerable attention has been paid to the use of topological derivative in topology optimization problems [3]. Certainly, large part of the topology optimization applications has been focused on computational design of structures, however, owing to the seminal work [1], it has been also applied to computational design of materials. To this aim, the microscopic topology is first designed by means of the topological derivative and then homogenized through a computational homogenization technique (FE^2).

The aim of this work is to design first the material in each point of the corresponding macrostructure [2]. For this propose, an alternate direction algorithm has been proposed to deal with the no-linearities of the problem. In addition, the high complexity and time-consuming computations of the problem has been solved by pre-computing the optimal microscopic topologies and by subsequently collecting them in a material catalogue (Computational Vademecum) so that, when optimizing the microstructures in the alternate direction algorithm, an straightforward selection of the optimal microstructure topology in the Computational Vademecum is required.

Then, on top of material design, even in a more stimulating fashion, the aim is to minimize a certain cost function (for instance the compliance of the structure) not only by designing the microscopic topology but also by designing the macroscopic topology. Some numerical examples exhibit the increase of the stiffness of the structures when considering designing the topologies in both scales. Finally, some manufacturable optimal designs have been obtained by adding constraints in the two-scale topology optimization problem.

References

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