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ON MULTI-SCALE STRUCTURAL TOPOLOGY OPTIMIZATION AND MATERIAL DESIGN

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Computational material design has gained considerable interest, along the last years, in the computational mechanics community [1][2][3]. Although most of the current approaches focus one-scale structural optimization, this work is settled in a multi-scale framework. In this sense, the goal consists of designing the micro-structure material and the macro-structure topology such that some cost function, is minimized. In this case, the structural compliance is the considered cost function, so that the structural stiffness is maximized for a given weight.

Solving the problem simultaneously (in both scales at the same time) becomes many times unaffordable because of its large algorithmic complexity and the involved computational cost. As a cost-reduction tool, an online-offline strategy, based on the off-line construction of a computational Vademecum [4], for the micro-structural optimization problem, and the on-line resolution of the structural equilibrium, is introduced. Then, the structural optimization problem can be reduced to a set of separable minimization problems at the micro-scale level, which are then quickly solved using the Vademecum-based strategy, this approaching real-time simulations.

The topological derivative concept is used as a tool for designing the topology at both, the macro and micro, scales. Some modifications on the algorithm proposed by Amstutz in [5], are done, in order to increase its robustness.

The macroscopic stresses and the macro and micro-structure topological description constitute the set of design variables to be determined by the multi-scale nonlinear coupled optimization problem. A fixed-point method, based on an alternate-directions strategy, is used as numerical technique for resolution of the non-linear problem.

The presented numerical results show the availability of the proposed approach to computational material design and structural optimization in a high-performance framework.