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OPTIMIZATION OF PERIODIC MICROSTRUCTURES USING SHAPE AND TOPOLOGY DERIVATIVES

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ABSTRACT

Optimization of 2D periodic microstructures is performed by using an alternate shape/topology optimization algorithm. This type of algorithm was introduced in [1] for optimizing 2D and 3D macroscopic structures. In the present work the implementation is different since we use mesh deformation and remeshing instead of the level set tool employed in [1]. Moreover, the approach is specific for periodic problems.

The problem under consideration is the following : in the elasticity framework, one is looking for the microstructure of a periodic composite whose response to prescribed effective strains is the best possible to achieve, with given materials and proportions.

Forthcoming from the homogenization theory, the analysis is made on a cellular problem (periodicity cell) with specific boundary conditions. The periodicity cell is defined through two given linearly independent vectors in $\mathbb{R}^2$. By this approach, the periodicity cell may be an arbitrary parallelogram.

Analytic expressions are computed for the shape derivative and for the topological derivative for a domain with periodic conditions on the boundary (periodicity cell). The shape and topology optimization steps correspond to steepest descent directions in the shape derivative and the topology derivative respectively. The algorithm performs several steps of shape optimization for each step of topology optimization. This ensures that stability is attained, due to the shape derivative, in the current topology class, and afterwards it is appropriate to change the class of topology of the domain.

A nonstructured triangular mesh is used, which is deformed at each shape optimization step. The topology variation is performed by choosing a vertex where the topological derivative has minimum negative value and by eliminating all its neighbour triangles. Remeshing is performed as needed through : redistribution of nodes, flipping of segments, mesh refinement. The code, written in FORTRAN 77, was developed in-house and uses the routines from [2]. The code is specific for periodic problems : the analysis is performed on a finite element mesh on the torus, followed by an unfolding operation in the sense of differential geometry.

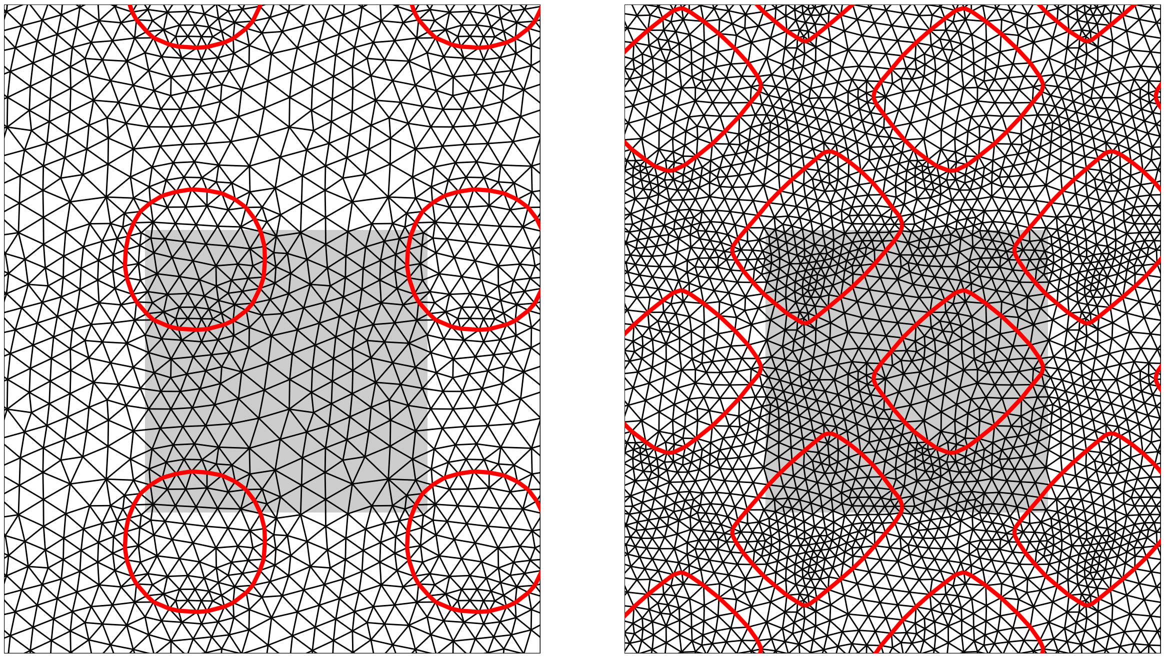

Figure 1: Initial guess and final design for the cellular microstructure for maximum shear response

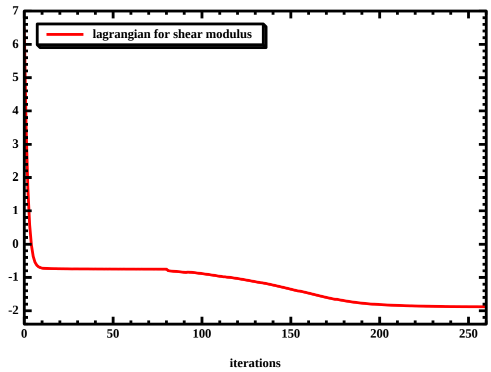

Figure 2: Convergence history

Numerical examples from [3] will be presented. Two possible approaches are also compared: the optimization of a perforated material against mixtures between the given material and a much weaker one.

REFERENCES

[1] G. Allaire, F. de Gournay, F. Jouve and A.-M. Toader, "Structural optimization using topological and shape sensitivity via a level set method". *Control Cybernet.*, Vol. **34**, no. 1, 59–80, 2005.

[2] C. Barbarosie, "Shape optimization of periodic structures". *Computational Mechanics*, Vol. **30** (3), 235–246, 2003.

[3] C. Barbarosie and A.-M. Toader "Shape and topology optimization of periodic structures". In preparation.