Emergence of elastostatic strain-gradient effects from topological optimization

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Résumé

In this presentation, we study and apply topological optimization techniques in order to synthesize microstructures featuring strain-gradient effects, in the framework of homogenized continuous materials in 2D. The method is based on the topological derivative (*Sokolowski and Żochowski 1999*).

We consider 2D periodic and continuous elastic materials, whose unit cell is composed of a rigid and a soft material. The associated Cauchy and strain-gradient homogenized tensors are formally derived with the classical two-scale asymptotic expansion method (see, e.g., *Jakabčin and Seppecher 2020*). Then, their topological derivatives are computed: namely, their sensitivity to an infinitesimal circular perturbation in the unit cell (see *Novotny and Sokolowski 2013* for a review, Garreau, *Guillaume, and Masmoudi 2001; Amstutz et al. 2010; Toader 2011* for Cauchy elasticity and microstrucures). We present the numerical method introduced in (*Amstutz and Andrä 2006*), which relies on the topological derivative. By applying this method within the strain-gradient framework, we obtain interesting microstructures featuring strain-gradient effects.

Finally, we discuss the limitations and improvements of this method, as well as other possible applications. In collaboration with Nicolas Auffray, we notably are interested in the optimization of functionals based on the invariants of the strain-gradient tensor (*Auffray, Abdoul-Anziz, and Desmorat 2021; Auffray, Desmorat, and Abdoul-Anziz 2021; Calisti 2021*).

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