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Multiscale IsoGeometric Design of Lattice Structures

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Using spline compositions leads to a convenient approach for the geometric modeling of (boundary-conforming) lattice structures. With this approach, the global (macro) geometry of the structure is represented employing a standard spline model. Then, reference micro-models (given as spline models too) are embedded into the macro-elements associated to the global geometry by the use of functional compositions.

Interestingly, such multi-scale geometric models are suitable for numerical simulation thanks to isogeometric analysis. This means that one unique model can be employed during design optimization [1]. However, there is a need for fast analysis methods in order to reduced the computational costs associated to these high-fidelity and high-order geometric models. To do so, we assemble the finite element operators with a multi-scale procedure [2]. Additionally, we built a specific solver based on domain decomposition methods [3]. Instead of solving one single large system, the resolution involves local problems defined over the sub-cells composing the full geometry. During both the assembly and the resolution, we exploit the similarities between these sub-cells. As a results, we end up with fast analysis methods that can be naturally integrated in a design loop. Finally, we perform several design optimization examples of innovative lattice structures in order to show the viability, the performance, and the great flexibility of the developed framework.

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