Isogeometric analysis for pantographic lattices under large nonlinear deformations

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ABSTRACT

Pantographic sheets are constituted by two orthogonal arrays of straight fibers inter-connected by internal pivots [1]. This metamaterial is gaining attention as it is extremely compliant toward large nonlinear deformations, while the behavior remains elastic. To model pantographic structures, a lattice of Euler–Bernoulli beams can be used. Alternatively, if the fibers are sufficiently dense, homogenization of the micro-structure results to a two-dimensional second-order gradient Cauchy continuum model.

The common point between the Euler–Bernoulli beam theory and this second-order gradient theory is that the energy is expressed in terms of second-order derivatives of the displacement field, such that classical finite elements cannot be directly used. As this is often done for Euler–Bernoulli beams, rotational degrees of freedom (dofs) can be introduced. However, this solution increases the computational cost (more dofs) and the matrices might be ill conditioned.

High-order shape functions used in isogeometric analysis allow the rotation-free solution of high-order problems, and this presentation demonstrates the advantage of its application to simulate pantographic structures. In addition, a particular attention is devoted to the use of the Mixed Integration Point (MIP) Newton, that combines the advantages of a pure displacement formulation (computation cost limited) and the ones of a mixed stress/displacement formulation (Newton more robust) to solve the geometrically-nonlinear problems.

REFERENCES

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