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Hybrid High-Order methods for finite deformations of hyperelastic materials

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We devise and evaluate numerically Hybrid High-Order (HHO) methods for hyperelastic materials undergoing finite deformations. HHO methods were introduced in [1] for linear elasticity and in [2] for diffusion problems. HHO methods use as discrete unknowns piecewise polynomials of order $k \geq 1$ on the mesh skeleton, together with cell-based polynomials that can be eliminated locally by static condensation. The discrete problem is written as the minimization of the broken nonlinear elastic energy where a local reconstruction of the displacement gradient is used. Two HHO methods are considered: a stabilized method where the gradient is reconstructed as a tensor-valued polynomial of order k and a stabilization is added to the discrete energy functional, and an unstabilized method which reconstructs a stable higher-order gradient and circumvents the need for stabilization. Both methods satisfy the principle of virtual work locally with equilibrated tractions. We present a numerical study of both HHO methods on test cases with known solution and on more challenging three-dimensional test cases including finite deformations with strong shear layers and cavitating voids (see [3]). We assess the computational efficiency of both methods, and we compare our results to those obtained with an industrial software using conforming finite elements and to results from the literature. Both HHO methods exhibit robust behavior in the quasi-incompressible regime.

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