High-Performance Model Order Reduction techniques for multiscale geometrical non-linear problems

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The purpose of this work is to generalize a version of the High Performance Reduced-Order Model (HPROM) technique, previously presented by the authors in [1], in the context of hierarchical multiscale models for heterogeneous non-linear-materials undergoing infinitesimal strains, is generalized to deal with a different range of applications. Typically, large elasto-plastic deformation problems subjected to small rotation regimes, observed in multiscale homogenization problems arising in a wide range of material modeling applications.

The proposed HPROM technique uses a Proper Orthogonal Decomposition (POD) procedure to build a reduced basis of the primary kinematical variable of the micro-scale problem, defined in terms of the micro-deformation gradient fluctuations. Then a Galerkin-projection, onto this reduced basis, is utilized to reduce the dimensionality of the micro-force balance equation. Finally, a reduced goal-oriented cubature rule is introduced to compute not only the non-affine terms of these equations, but also the stress homogenization tensor and the equivalent macro-constitutive tangent tensor equation.

The work is focused on the numerical assessment of the HPROM technique. The numerical experiments are performed on a micro-cell simulating a randomly distributed set of elastic inclusions embedded into an elasto-plastic matrix. This micro-structure is representative of a typical ductile metallic alloy. The HPROM technique applied to this type of problem displays high computational speed-ups, increasing with the complexity of the finite element model. We conclude that this technology is adequate for applications in material modeling involving two length scales.

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