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Registration-based model reduction of parameterized PDEs with spatio-parameter adaptivity.

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We present a nonlinear registration-based model reduction procedure for rapid and reliable solution of parameterized two-dimensional steady conservation laws. This class of problems is challenging for model reduction techniques due to the presence of nonlinear terms in the equations and also due to the presence of parameter-dependent sharp gradient regions that cannot be adequately represented through linear approximation spaces. Our approach builds on the following ingredients: (i) a general (i.e., independent of the underlying equation) registration procedure for the computation of a parametric mapping that tracks moving features of the solution field; (ii) an hyper-reduced least-squares Petrov-Galerkin reduced-order model for the rapid and reliable estimation of the solution field; (iii) a greedy procedure driven a residual-based error indicator for efficient exploration of the parameter domain; and (iv) an adaptive mesh refinement technique for the definition of an accurate discretization for all parameter values. We present results for several nonlinear problems in continuum mechanics to demonstrate the effectiveness and the mathematical soundness of our proposal.

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