A Reduced-Order Model based in nonlinear multidimensionality reduction: a kernel Proper Orthogonal Decomposition.

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Aiming at obtaining multiple solutions of a parametric problem, one of the more popular a posteriori methodology for Reduced-Order Models is the Proper Orthogonal Decomposition (POD). It is a combination of Reduced Basis (RB) approach with a Principal Component Analysis (PCA). The parametric space is sampled by computing a sufficiently large number of snapshots that acts as training set. PCA allows discovering a linear manifold containing the family of parametric solutions and the RB strategy solves a reduced problem of size equal to the dimension of this linear manifold. The kPOD (k stands for kernel) is a nonlinear dimensionality reduction technique that aims at discovering low-dimensional non-Euclidean manifolds containing the family of solutions and to solve the problem in this "small" set of functions. The kPOD uses kPCA as an alternative to PCA, which relies in a kernel to be selected by the user. In order to improve the reduction capacity of the method, the ad-hoc kernels are selected on the basis if the physics of the problem, using functional extractors of the features that distinguish the different solutions in the family. The reduced-order solver has to browse the reduced space in order to select the best approximation to the actual solution. Different exploration strategies are discussed, and their computational performance is demonstrated in examples from different disciplines.

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