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An algebraic approach to deal with nonlinearities in reduced basis methods: the matrix discrete empirical interpolation

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The low cost associated with the solution of reduced order models (ROMs) has in turn allowed their use to accelerate real-time analysis, PDE-constrained optimization [2, 4, 5] and uncertainty quantification [3] problems. In all these cases a suitable offline/online stratagem becomes mandatory to gain a strong computational speedup. However, the complex parametric dependence of the discretized PDE operators, as well as the nonlinear and (possibly, unsteady) nature of the equation, have a major impact on the computational efficiency.

In this talk we show how to apply a Matrix version of the so-called Discrete Empirical Interpolation (MDEIM) for the efficient reduction of nonlinear and nonaffine systems arising from the discretization of parametrized PDEs [1]. Dealing with affinely parametrized operators is crucial in order to enhance the online solution of ROMs such as the reduced basis method [6]. However, in many cases such an affine decomposition is not readily available, and must be recovered through (often) intrusive procedures, such as the empirical interpolation method (EIM) and its discrete variant DEIM. The MDEIM approach presented in this talk allows instead to deal with nonlinearities, as well as with non affinities arising from complex physical and geometrical parametrizations, in a non-intrusive, efficient and purely algebraic way. We propose different strategies to combine MDEIM with a state approximation resulting either from a greedy algorithm or Proper Orthogonal Decomposition. The capability of MDEIM to generate accurate and efficient ROMs is demonstrated on the solution of some computationally-intensive classes of problems occurring in engineering contexts, namely parametrized coupled problems, PDE-constrained optimization and uncertainty quantification problems.

References

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