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STATE OF THE ART AND PERSPECTIVES FOR REDUCED ORDER METHODS IN INDUSTRIAL COMPUTATIONAL FLUID DYNAMICS

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We provide the state of the art of Reduced Order Methods (ROM) for parametric Partial Differential Equations (PDEs), and we focus on some perspectives in their current trends and developments, with a special interest in parametric problems arising in offline-online Computational Fluid Dynamics (CFD) with application in industry.
Efficient parametrisations (random inputs, geometry, physics) are very important to be able to properly address an offline-online decoupling of the computational procedures and to allow competitive computational performances. Current ROM developments in industrial CFD include: a better use of stable high fidelity methods, considering also spectral element method, discontinuous Galerkin and finite volume discretisations, to enhance the quality of the reduced model too, and allowing to incorporate some turbulent patterns, as well as increasing the Reynolds number; more efficient sampling techniques to reduce the number of the basis functions, retained as snapshots, as well as the dimension of online systems; the improvements of the certification of accuracy based on residual based error bounds and of the stability factors, as well as the guarantee of the stability of the approximation with proper space enrichments. For nonlinear systems, also the investigation on bifurcations of parametric solutions are crucial and they may be obtained thanks to a reduced eigenvalue analysis of the linearised operator. All the previous aspects are very important in CFD problems to focus in real time on complex parametric industrial, environmental and biomedical flow problems, or even in a control flow setting with data assimilation or uncertainty quantification. Model flow problems will focus on some benchmarks of interest, as well as on simple fluid-structure interaction problems and shape optimisation applied to industrial