Reduced-Order Models: Convergence Between Data and Simulation

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How to revisit computational schemes using new data-based modeling approaches in order to reduce computational costs, improve the accuracy of simulation codes in situations where the physical model is incomplete, allow realignment with respect to experimental tests...?

This is a widespread issue in industry since despite advances in high-performance computing, numerical models remain heavy and their exploitation to explore the parametric space is prohibitive in actual applications. Techniques allowing considerable acceleration of this exploration have appeared in recent years by model reduction from data. A reduced-order model (ROM) is based on an initial offline sampling phase of the PDE solution in order to collect data. The solution datatset is then used to define a reduced approximation space compared to the dimension of the high-fidelity model. Finally, in the online phase, the PDE solution is sought in the reduced space.

Each of the steps of a ROM implies modelling choices about how to effectively sample the solution space, how to define the approximation space from the sampling, how to determine the solution that best approximates the PDE in this space. These modelling choices rely on ideas from numerical analysis, geometry and optimisation: residual minimisation, optimal transport theory, interpolation on geodetics.

Through the study of some realistic applications in industry, we will discuss the implementation of these reduced-order methods for the equations of Navier-Stokes, compressible Euler, BGK, advection diffusion reaction, concluding on the perspectives of convergence between data and EDP models.

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