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Reduced Order Models with (and for) goal-oriented error assessment

Pedro Díez[1], Núria Parés[1], Sergio Zlotnik[1], Francesc Verdugo[1], Antonio Huerta[1]

[1] Laboratori de Càlcul Numèric (LaCaN), Universitat Politecnica de Catalunya (UPC BarcelonaTech), Campus Nord UPC, Mòdul C2, E-08034 Barcelona, Spain
pedro.diez@upc.edu; http://www.lacan.upc.edu

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Reduced order models (ROM) drastically reduce the order of complexity and computational cost of the numerical simulation. This is essential in facing different Computational Mechanics challenges: 1) real time simulations, 2) stochastic modeling and 3) optimization and parameter identification. The drastic reduction in terms of cost is assumed not to undermine the accuracy of the numerical solution. Thus, it is crucial to monitor the quality of the ROM solution, using an error assessment tool. The approach presented in [1] and [2] for different ROM techniques consists in taking a richer approximation of the adjoint problem and injecting it into the residual of the direct problem in order to obtain an estimate of the error in the Quantity of Interest.

Any ROM uses a reduced basis of the complete FE space, which for error assessment purposes is taken as a reference. This basis is constructed after a series of "snapshots" (standard RB, POD) or term after term using some greedy strategy (also complemented by a separation of variables, as in the PGD approach). For the viewpoint of error estimation, it is not relevant how the basis is selected, the estimators work for any ROM approach. It is worth noting that it is important separating the error coming from the FE discretization and the one originated in the ROM. Thus, the aim of the ROM error estimator is to assess the difference between the ROM solution and the full FE solution, which is taken as a reference solution. Note that this is essential to decide if the FE mesh or the ROM are to be refined.

Complementarily, ROM are also useful in the standard FE error estimation techniques because the may provide an accurate solution of the adjoint solution that can be used to assess the FE error (the one introduced by the coarseness of the mesh). This idea was already introduced in [3] using a modal description as a primitive ROM.

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