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REDUCED ORDER MODELING FOR UNCERTAINTY QUANTIFICATION IN SUBSURFACE FLOW PROBLEMS

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ABSTRACT

Uncertainty Qualification (UQ) tasks relies on repeated runs of a computationally expensive simulation codes. The number of required runs grows exponentially with the number of uncertain model parameters in what is known as the curse of dimensionality. One technique to address the high computational demands of UQ tasks is to replace the high fidelity full physics model with an approximate Reduced Order Model (ROM). The process of constructing reduced order models relies on learning the full physics system behaviour using a representative set of high fidelity runs [2] and/or using a simplified physical model retaining the key physical interactions within the system [1].

In this mini-symposium recent advances in uncertainty quantification, optimal control and robust optimisation using reduced order models will be discussed. This includes various model reduction techniques including: (a) projection based methods (e.g. proper orthogonal decomposition, greedy reduced basis, discrete empirical interpolation), (b) data-driven methods utilising response surface approaches (e.g. polynomial chaos expansion, machine learning) and (c) reduced physics and system identification methods. Topics of interests also include: error estimation for reduced order models, sparse representation, nonlinearity parametrization, optimal basis functions/snapshots extraction, localization techniques and model cross-validation methods. Additionally, the different uses of ROMs in subsurface flow problems are of interest including: uncertainty quantification, optimal control and robust design using gradient based methods, Bayesian statistics, and multi-level/multi-fidelity Markov chain Monte-Carlo approaches.

REFERENCES

[1] Laureline Josset, Vasily Demyanov, Ahmed H. Elsheikh, Ivan Lunati, Accelerating Monte Carlo Markov chains with proxy and error models, Computers & Geosciences, Volume 85, Part B, December 2015, Pages 38-48, https://doi.org/10.1016/j.cageo.2015.07.003.

[2] Xiao, D., Lin, Z., Fang, F., Pain, C. C., Navon, I. M., Salinas, P., and Muggeridge, A. (2017) Non-intrusive reduced-order modeling for multiphase porous media flows using Smolyak sparse grids. International Journal for Numerical Methods in Fluids, 83: 205–219. https://doi.org/10.1002/fld.4263