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About the possibilities of reduced basis to couple data assimilation, interpolation and domain decomposition for the real-time simulation of experiments

Olga Mula Hernandez (UPMC/LJLL & CEA)

The parareal in time algorithm is a domain decomposition method for the time variable that allows to get additional speed-ups in the resolution of time-dependent PDE's when other efficient parallelization methods (like, e.g., spatial domain decomposition) reach saturation. The key ingredients of the algorithm are, first of all, the use of two propagators $\mathcal{F}$ and $\mathcal{G}$ that, taking an initial value at a given time t respectively provide a fine and coarse approximation to the solution at a later time $t+\tau$. Then, if the total interval of time $[0,T]$ is dived into N subintervals $[T_n, T_{n+1}]$ ($0 \le n < N$) the algorithm proposes to combine these two propagators in a predictor-correction fashion in order to build a sequence X_k^n that converges to the fine solution X^n at time T_n as k tends to infinity (and for all $0 \le n \le N$).

In recent years, there has been a considerable effort to improve the performances of the method by reducing the cost of the fine propagator inside the parareal iterations. In [1]for example (see also 2]) it has been proposed to use a domain decomposition algorithm to compute the fine solver and to limit the number of (domain decomposition) iterations during each (parareal) iterations and to resume the iterations by using the previous state as an initial guess in the further domain decomposition iterations. In this spirit, we propose to adapt this strategy to the case where the fine solver presents internal iterations and, in this talk, we will present a scheme in which the internal iterations are truncated and the convergence is obtained across the parareal iterations. After a convergence analysis, we will show some numerical results dealing with the application of the scheme to accelerate the time-dependent neutron diffusion equation in a reactor core and we will show how the use of a reduced basis can alleviate the high memory storage demand that the proposed method requires.

References:

[1] Maday, Y. and Turinici, *The Parareal in Time Iterative Solver: a Further Direction to Parallel Implementation*, 2005, Domain Decomposition Methods in Science and Engineering, Springer Berlin Heidelberg, 441-448,
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[2] Guetat, R., Méthode de parallélisation en temps: Application aux méthodes de décomposition de domaine, Thèse Paris VI, 2012