A Parareal Algorithm with Spectral Coarse Solver

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(joint work with Martin Gander and Mario Ohlberger)

We present a new class of Parareal algorithms for parabolic PDEs, where the coarse solver for each time interval is given by a spectral approximation of the transfer operator mapping initial values at the beginning of the interval to the solution at its end. As high-frequency oscillations are quickly damped over time, these transfer operators exhibit a fast singular value decay, so a low-rank approximation is possible. The approximations are obtained embarrassingly parallel by using a randomized singular value decomposition, which only requires local fine solutions for random initial values. We provide a posteriori error bounds for the Parareal approximation error in terms of norms of local updates and the computed singular values of the transfer operators. Our numerical experiments show that our approach can significantly outperform Parareal with basic single-step coarse solvers. At the same time, it allows to further increase parallelism by trading coarse updates by a larger number of local solutions.