Parallel-in-Time Multirate Explicit Stabilized method for the Monodomain model in Cardiac Electrophysiology*

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Abstract

The monodomain model is widely used in cardiac electrophysiology to simulate the electric potential propagation in the heart. It is composed of a parabolic equation and, for each discretization node, a ionic model consisting in a system of tens to hundreds of multiscale ordinary differential equations. The monodomain model is oftentimes solved employing parallel spatial discretization techniques rapidly incurring into bandwidth saturation. The aim of our research is to explore the efficiency of the Parareal framework applied to the monodomain model.

Despite its stringent stability restrictions the explicit Euler scheme is still very popular in the cardiac simulation community due to its easiness of implementation and favourable scaling properties. To preserve such appreciated features but remove any step size restriction, that would limit the coarse propagator in Parareal, our approach is based on: 1) multirate explicit stabilized Runge–Kutta methods, whose work load if barely affected by a few severely stiff terms; 2) in conjunction with splitting techniques and the exponential Euler method on stiff scalar terms (i.e. the popular Rush–Larsen method employed in cardiac community).

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