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A domain decomposition strategy for a very high-order finite volumes scheme applied to cardiac electrophysiology

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SUMMARY

The propagation of an electrical action potential in the heart may be modelled by the monodomain model:

$$\partial_t V + I_{ion}(V, w) = \div D\nabla V, (1), \qquad \partial_t w = G(V, w), (2)$$

where V is the transmembrane voltage, $I_{ion}(V, w)$ is the normalized ionic current, and D is the normalized diffusion tensor. Equation (2) is the system of m nonlinear ordinary differential equations called the ionic model, and specified through the function $G(V, w)$. Let us mention that realistic ionic models are stiff and contain some variables which lie into a domain of admissibility (e.g. ionic concentrations). Moreover, this model generates the propagation of very stiff depolarization fronts. These difficulties and the fact that simulations are required on long periods of time make the design of efficient numerical schemes critical. We will introduce the scheme proposed in [1], which approximates the solutions of (1)-(2). It is a very high-order scheme (up to order 6) based on a MOOD paradigm with two polynomial reconstructions: one on the cells et the other on the interfaces (see references therein and also [2]). Furthermore, in order to be able to perform realistic computation, we propose a domain decomposition method: the computational domain is divided into subdomains and the reconstruction stencils are adapted to theses subdomains. In particular, they are forced to stay either in the subdomain or in the immediate vicinity of it (typically in the first layer of cells). In the presentation, we will detail the procedure and the different validation test-cases which show the techniques efficiency.

References

[1] Y. Coudiére and R. Turpault Very high order finite volume methods for cardiac electrophysiology. *Comp. Math. Appli.* **74**(4), 2017.

[2] S. Clain, G.J. Machado, J.M. Nóbrega and R.M.S. Pereira A sixth-order finite volume method for multidomain convection-diffusion problem with discontinuous coefficients. *CMAME* **267**, 2013

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