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Preconditioning Techniques for the Bidomain Equations

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Abstract: In this work we discuss parallel preconditioning techniques for the bidomain equations. The bidomain model has been widely used for the simulation of electrical activity in cardiac tissue. The equations arise from electrostatic formulations describing the potentials in the intracellular and extracellular tissue domains which are coupled through a non-linear model describing the current flow through the cell membrane.
We approached the non-linear system of partial differential equations with an operator splitting technique. Our numerical algorithm is based on a three step scheme which involves the solution of a parabolic equation, an elliptic equation and a non-linear system of ordinary differential equations at each time step. We focused on the solution of the linear system associated with the elliptic part of the bidomain model, since it dominates computation, with the preconditioned conjugate gradient method. We compared different parallel precondictioning techniques, such as Jacobi, block incomplete LU, Gauss-Seidel, additive Schwarz and different multigrid methods. The implementation is based on the Petsc library and we report results for a 16 node HP cluster (each node consists of two McKinley 900 MHz CPU's with 2 GB RAM).
The results suggest the multigrid preconditioner is the best option for the bidomain equations.

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