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The anisotropic Bidomain model of electrocardiology: a comparison of coupled and uncoupled parallel preconditioners

The anisotropic Bidomain model describes the bioelectric activity of the cardiac tissue and consists of a system of a parabolic non-linear partial differential equation (PDE) and an elliptic linear PDE. The PDEs are coupled with a system of ordinary differential equations (ODEs), modeling the cellular membrane ionic currents. The discretization of the Bidomain model in three-dimensional (3D) ventricular geometries of realistic size yields the solution of large scale and ill-conditioned linear systems at each time step. The aim of this work is to construct and study parallel multilevel and block preconditioners, in order to strongly reduce the high computational costs of the Bidomain model, allowing the simulation of the whole heart beat in 3D realistic domains. We analyze the scalability of multilevel Schwarz block-diagonal and block-factorized preconditioners for the Bidomain model and compare them with multilevel Schwarz coupled preconditioners. 3D parallel numerical tests show that block preconditioners are scalable, but less efficient than the coupled preconditioners. Finally, we present simulations of the cardiac *virtual electrode* phenomenon, yielding anode make and break mechanisms of excitation, using the developed parallel solver.