SCALABLE PRECONDITIONED NEWTON–KRYLOV AND QUASI–NEWTON SOLVERS FOR NONLINEAR CARDIAC MODELS

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Abstract. This talk focuses on preconditioned Newton–Krylov and quasi-Newton solvers for the solution of the nonlinear cardiac models arising in electrophysiology and cardiac mechanics. The preconditioners that we consider belong to the classes of both Algebraic Multigrid Methods (AMG) and Dual-Primal Domain Decomposition, such as Balancing Domain Decomposition by Constraints (BDDC) and Dual-Primal Finite Element Tearing and Interconnecting (FETI-DP). We first study the performance of AMG and BDDC preconditioners in a Newton–Krylov solver for cardiac mechanics, varying the choice of BDDC local and coarse solvers, primal degrees of freedom, finite element degree and investigating the strong scalability of the solvers [1]. We also study alternative nonlinear solvers for cardiac mechanics where the classical Newton – Krylov method is replaced by inexact Newton–Krylov and quasi-Newton methods, varying the problem size, data magnitude and number of processors, showing in some cases a significant speed-up over the standard Newton–Krylov method [2]. BDDC and FETI-DP preconditioners with deluxe scaling can also be applied to Newton–Krylov solvers for the Bidomain model in cardiac electrophysiology where a polylogarithmic convergence rate bound can be proven and validated by parallel numerical tests, showing that the proposed parallel solvers are scalable and quasi-optimal [3]. Ongoing work is investigating the extension of Quasi-Newton solvers to implicit Bidomain discretizations [4].

Keywords: Newton–Krylov methods, Quasi-Newton, domain decomposition methods, algebraic multigrid, FETI-DP and BDDC preconditioners, nonlinear elasticity, bidomain system.

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