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Adaptive preconditioners for Newton-Krylov methods

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The use of preconditioned Newton-Krylov methods is in many applications mandatory for computing efficiently the solution of large nonlinear systems of equations. However, the available preconditioners are often sub-optimal, due to the changing nature of the linearized operator. This the case, for instance, for quasi-Newton methods where the Jacobian (and its preconditioner) are kept fixed at each non-linear iteration, with the rate of convergence usually degraded from quadratic to linear. Updated Jacobians, on the other hand require updated preconditioners, which may not be readily available. In this work we introduce an adaptive preconditioning technique based on the Krylov subspace information generated at previous steps in the nonlinear iteration. In particular, we use to advantage a deflation technique suggested in [1] for restarted GMRES to enhance existing preconditioners with information about (almost) invariant subspaces constructed by GMRES at previous stages in the nonlinear iteration. We provide guidelines on the choice of invariant-subspace basis used in the construction of our preconditioner and demonstrate the improved performance on various test problems. As a useful general application we consider the case of augmented systems preconditioned by block triangular matrices based on the structure of the system matrix. We show that a sufficiently good solution involving the primal space operator allows for an efficient application of our adaptive technique restricted to the space of dual variables.

[1] J. Baglama, D. Calvetti, G. H. Golub, and L. Reichel. Adaptively preconditioned GMRES algorithms. SIAM J. Sci. Comput., 20(1):243–269 (electronic), 1998.