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Nonlinear Adaptive Smoothed Aggregation Multigrid

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The increasing demands of large-scale complex solid mechanics simulations areplacing greater emphasis on the challenges associated with the efficient solution of the set of nonlinear equations. Here, the solution of large systems of equations with material, geometric and contact nonlinearities in a parallel framework is adressed. Instead of applying widely used Newton- or Newton-Krylov type methods that involve the derivation of a stiffness matrix and a sequence of linear solves, the presented work details the implementation of a variational nonlinear algebraic multigrid algorithm based on the full approximation scheme (FAS) applied to solve this set of nonlinear equations [2]. The multigrid hierachy is constructed using an adaptive smoothed aggregation multigrid approach [1],[5] applied to a fine grid Jacobian that will also be used to construct nonlinear smoothers on all grids. As the variational evaluation of the nonlinear residual function plays a crucial role for the cost of the overall method, reducing the number of residual evaluations by encountering the extra effort of a (linear) adaptive smoothed aggregation procedure can reduce overall solution times significantly. The algorithm is implemented within Sandia National Laboratories' freely available parallel 'Trilinos' linear algebra framework[3] and makes use of it's smoothed aggregation multigrid library 'ML' [4] and it's nonlinear solver library 'NOX'. The outline of the algorithm and implementation are given together with examples demonstrating the advantages of this new approach. Several variants of the algorithm will be discussed and compared.

References

[1] Brezina, M. et al., R., "Adatpive Smoothed Aggregation (aSA) Multigrid", SIAM Review, 47, 317-346, 2005.

[2] Gee, M.W., Tuminaro, R.S. , "Nonlinear algebraic multigrid for constrained solid mechanics problems using Trilinos", technical report, Sandia National Laboratories. 2006, to appear.

[3] Heroux, M.A., Willenbring, J.M., "Trilinos Users Guide", Sandia Report SAND2003-2952, 2003.

[4] Sala, M., Hu, J.J., Tuminaro, R.S., Gee, M.W., "ML 4.0 Smoothed Aggregation User's Guide", Sandia Report SAND2004-2195, 2004.

[5] Vanek, P., Mandel, J., Brezina, M., "Algebraic Multigrid by Smoothed Aggregation for Second and Fourth Order Elliptic Problems", Computing, v. 56, p. 179-196, 1996.