Annual Progress Report for 2004 of the project P14953

Robust Algebraic Multigrid Methods and their Parallelization

The aim of the project, that started 1st of October 2001, consists in the construction of robust, flexible and efficient Algebraic Multigrid (AMG) methods, their parallelization, and their applications to real life problems. The following progress has been made since the last Annual Report 2003:

1. The results of M. Wabro about coupled algebraic multigrid methods for the Oseen equations have recently been published in the journal *Computing and Visualization* [15].

2. Extensions to the element based AMG (AMGe) methods concerning the agglomeration process, the application to non-conforming elements and the application to the mixed finite element discretization of the Oseen-linearized Navier-Stokes equations have been provided by M. Wabro. A corresponding paper is accepted for publication in the *SIAM Journal for Scientific Computing* [16] (a preprint is also available [14]).

3. Concerning multigrid methods for boundary element equations, we have compared the numerical features like convergence rate, solution time and memory consumption for geometric and algebraic multigrid variants in [5]. These results and new convergence analysis results for the geometric multigrid methods were presented by D. Pusch [12].

4. The results on data-sparse algebraic multigrid methods for large-scale boundary element equations were presented on the 16th FEM symposium 2003 and were accepted for publication in the journal *Applied Numerical Mathematics* [6].

5. In order to construct efficient iterative multigrid solvers for boundary element matrices the application of approximation techniques is absolutely necessary. We first focus on low-rank matrices approximation [13], but one can also think of data-sparse multigrid versions based multipole methods. G. Of from the University Stuttgart and D. Pusch have discussed and implemented this idea.

6. In [7], U. Langer and O. Steinbach introduced the coupled FETI/BETI method for solving potential problems. Numerical results can be found in [4] and were presented by A. Pohoata in a talk at the University of Stuttgart [11]. C. Pechstein extended the FETI/BETI-technique to nonlinear potential equations [8]. U. Langer gave a plenary talk on primal and dual domain decomposition methods at the Annual GAMM meeting in Dresden [3].

7. Multigrid-Newton-Methods for nonlinear magnetostatic problems were studied in C. Pechstein's diploma thesis [9], which was supported by a "Kleine Forschungsbeihilfe" of the project P14953. An extension to Pechstein's diploma thesis was the investigation of monotonicity-preserving interproximations of B-H-curves [10].

8. The paper on multiharmonic techniques for nonlinear eddy current problems by F. Bachinger, U. Langer and J. Schöberl was accepted for publication in the journal *Numerische Mathematik* [1]. F. Bachinger was also supported by "Kleine Forschungsbeihilfe" of the project P14953. U. Langer gave a plenary talk on these results at the ECCOMAS 2004 in Jyväskylä, Finland [2].

All results, including the publications as well as this report, can be found on our project homepage

`http://www.numa.uni-linz.ac.at/Research/Projects/P14953.html`

References

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[4] U. Langer, A. Pohoata, and O. Steinbach, *Application of Preconditioned Coupled FETI/BETI Solvers to 2D Magnetic Field Problems*, SFB-Report 2004-23, JKU Linz, 2004.

[5] U. Langer and D. Pusch, *Comparison of Geometrical and Algebraic Multigrid Preconditioners for Data-Sparse Boundary Element Matrices*, SFB-Report 2004-24, Johannes Kepler University Linz, 2004.

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[11] A. Pohoata, *Application of Preconditioned Coupled FETI/BETI Solvers to 2D Magnetic Field Problems*, Talk at University Stuttgart, Institut für Angewandte Analysis und Numerische Simulation, July 21 – 22, 2004.

[12] D. Pusch, *Comparison of Geometric and Algebraic Multigrid for Data-Sparse Boundary Element Matrices*, Talk at BEM Workshop on Adaptive Fast Boundary Element Methods in Industrial Applications, Söllerhaus, September 29 – October 2 2004.

[13] ———, *Multigrid Preconditioners for Low-Rank Approximations of Boundary Element Matrices*, Talk at University Stuttgart, Institut für Angewandte Analysis und Numerische Simulation, November 22 – 26 2004.

[14] M. Wabro, *AMGe - Coarsening Strategies and Application on the Oseen-Equations*, SFB-Report 2004-12, Johannes Kepler University Linz, 2004.

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[16] ———, *AMGe - Coarsening Strategies and Application to the Oseen-Equations*, SIAM Journal for Scientific Computing (2005), (accepted for publication).