Annual Progress Report for 2002 of the project P14953

Robust Algebraic Multigrid Methods and their Parallelization

The aim of the project, that started 1^{st} 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 2001:

1. In paper [9], which was written together with J. Schicho (RISC, University of Linz), we extended our work concerning the element preconditioning technique in such a way that symbolic methods are now used for the solution of the small optimization problems arising in our preconditioning algorithm. This symbolic solver improves the efficiency significantly.

2. Concerning our work on source reconstruction in the human brain, which is a joint work with C. Wolters et al. (MPI-Leipzig, Germany), we were invited to write a chapter of a book [17]. A detailed description and analysis of our parallel algebraic multigrid solver for large scale finite element equations arising from the source localization in human brains can be found in the journal publication [18]. Additionally we improved our common code NeuroFEM-Pebbles by the parallel implementation of simultaneous right hand sides [1]. This is based on paper [4] where the technique of simultaneous right hand sides was suggested.

3. M. Kaltenbacher (University of Erlangen, Germany) and S. Reitzinger were invited to write a paper for the COMPUMAG society, concerning AMG for 3D magnetic field problems [5]. In this article we give a survey on the latest developments related to fast solvers for 3D magnetics.

4. On the conference "Scientific Computing in Electrical Engineering" (SCEE-2002), we presented a poster on the PEBBLES software and its application to non-linear magnetic field problems [3].

5. We have continued our work on the construction of AMG preconditioners for matrices typically arising in the Galerkin and collocation boundary element methods (BEM). The first results will appear in the journal publication [8] and were presented in the talk [6]. The standard boundary element methods produce fully populated matrices. To overcome this bottleneck of the standard boundary element methods, sparse approximation techniques have been developed during the last decade. We have constructed new AMG preconditioners for Adaptive Cross Approximation (ACA) Boundary Element Matrices. Our diploma student D. Pusch implemented these AMG preconditioners for ACA matrices in the program package PEBBLES and worked on this topic in the framework of his diploma theses [12]. The first results were presented on a special BEM workshop by D. Pusch [11]. A publication on AMG preconditioners for ACA matrices is in preparation. O. Steinbach and U. Langer have developed the Boundary Element Tearing and Interconnecting (BETI) Method as a very efficient parallel solver for large scale boundary element equations [10]. These results were presented by U. Langer at an Oberwolfach conference [7]. The technique can be used for constructing parallel AMG preconditioners.

6. Two other diploma students have been supported by the FWF via "Kleine Forschungsbeihilfe". F. Bachinger works on the harmonic balance finite element method. This is an extension of the work 'AMG for complex symmetric matrices' [14], but now nonlinear time-harmonic equations are considered [2]. The second diploma student, C. Pechstein, is concerned with the fast and efficient solution of nonlinear (magnetic) field problems. The topic is related to a quasi full multigrid approach, but based on AMG ideas. Furthermore a paper on the approximation of material data was written [13].

7. M. Wabro's AMG-solver for (incompressible) Navier-Stokes equations AMUSE has now come to a point, where the simulation of flows in complex 3D geometries can be performed with

reasonable computational effort. This was possible as theoretical investigations have revealed possible stability problems on coarse levels, which can be solved under certain requirements on elements and/or coarsening strategies. The results were presented on the international conference *"Challenges in Scientific Computing"* at Berlin (Germany) [15] and on the *"European Multigrid Conference"* in Hohenwart (Germany) [16]. Publications are in preparation.

All results including the publications can be found on our project home-page

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

References

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