Technische Universität Graz

6. Workshop on

Fast Boundary Element Methods in Industrial Applications

Söllerhaus, 2.–5.10.2008

U. Langer, O. Steinbach, W. L. Wendland (eds.)

Berichte aus dem Institut für Numerische Mathematik

Book of Abstracts 2008/4

Technische Universität Graz

6. Workshop on

Fast Boundary Element Methods in Industrial Applications

Söllerhaus, 2.–5.10.2008

U. Langer, O. Steinbach, W. L. Wendland (eds.)

Berichte aus dem Institut für Numerische Mathematik

Book of Abstracts 2008/4

Technische Universität Graz
Institut für Numerische Mathematik
Steyrergasse 30
A 8010 Graz

WWW: `http://www.numerik.math.tu-graz.ac.at`

Program

Friday, 3.10.2008	
9.00–9.30	W. L. Wendland (Stuttgart) The Gauss problem
9.30–10.00	H. Harbrecht (Bonn) Fast methods for 3D Electric Impedance Tomography
10.00–10.30	S. Engleder (Graz) The mathematical model of the forward problem of MIT
10.30–11.00	Coffee
11.00–11.30	D. Lukas (Ostrava) Optimal shape design for nonlinear axisymmetric magnetostatics using a coupled FEM-BEM scheme
11.30–12.00	D. Pusch (Baden) Impact of basis functions in BEM (FEM) calculation of eddy current problems
12.00–12.30	C. Jerez-Hanckes (Zürich) A hybrid BEM formulation for surface acoustic wave interdigital transducers modelling
12.30	Lunch
15.00–15.30	Coffee
15.30–16.00	A. Salvadori (Brescia) Analytical integrations in 3D BEM for hyperbolic problems
16.00–16.30	S. Ferraz–Leite (Wien) Simple a posteriori error estimators for boundary element methods in 3D
16.30–17.00	C. Fasel (Saarbrücken) Advances in nonlocal electrostatics
17.00–17.30	Break
17.30–18.00	M. Radrainarivony (Bonn) Hierarchical surface mesh generation for wavelet BEM solvers
18.00–18.30	G. Haase (Graz) GPU accelerated algorithms
18.30	Dinner

Saturday, 4.10.2008	
9.00–9.30	Z. Andjelic (Baden) BEM based component-level optimisation
9.30–10.00	J. E. Ospino (Hannover) A skin effect approximation for three–dimensional eddy current problems
10.00–10.30	M. Fleck (Saarbrücken) Higher-order Whitney forms
10.30–11.00	Coffee
11.00–11.30	T. Samrowski (St. Augustin) An adaptive fast multipole method for the rapid solution of the stationary linearized Navier-Stokes system
11.30–12.00	A. Radcliffe (Hannover) Mixed finite element/boundary element coupling for the two–dimensional exterior Stokes problem
12.00–12.30	L. Raguin (Zürich) Spectral Fourier methods with projectors of the Calderon type for surface plasmon polaritons ehanced nanostructures
12.30	Lunch
13.30–18.00	Hiking tour
18.30	Dinner
Sunday, 5.10.2008	
9.00–9.30	P. Urthaler (Graz) Modelling of poroelastic materials
9.30–10.00	M. Messner (Graz) Accelerating an elastodynamic boundary element formulation by using adaptive cross approximation
10.00–10.30	Coffee
10.30–11.00	R. Grzibovski (Saarbrücken) Modelling the elastic properties of composite materials using BEM
11.00–11.30	W. Elleithy (Linz) On the adaptive coupling of finite elements and boundary elements for three-dimensional elasto-plastic analysis
11.30	Closing

BEM–Based Component-Level Optimization

Z. Andjelic, D. Pusch, I. Erceg
ABB Corporate Research Switzerland

Here we give a brief description of the BEM-based procedures for the component-level optimization of practical apparatus. After some information on the non-parametric, non-gradient formulation we proceed with the corresponding numerical implementation. Finally, the application of the developed procedures is illustrated on the optimization of some real-world problems.

On the Adaptive Coupling of Finite Elements and Boundary Elements for Three-Dimensional Elasto-Plastic Analysis[1]

W. Elleithy, U. Langer
Johannes Kepler Universität Linz

We present adaptive finite element-boundary element coupling method (FEM-BEM) for solving problems in elasto-plasticity. The adaptive coupling method presented takes care of the evolution of the elastic and plastic regions and avoids limitations of the standard FEM-BEM coupling approaches. We propose the use of simple, and at the same time fast, post calculations, based on energetic methods which follow simple hypothetical elastic computations, in order to obtain fast and helpful estimation of the FEM and BEM sub-domains. The FEM and BEM meshes are automatically generated over the estimated plastic and the remaining linear elastic regions, respectively. Furthermore, FEM and BEM sub-domains are progressively adapted according to the state of computation.

The results for two- and three-dimensional applications in elasto-plasticity show the practicality and the efficiency of the adaptive FEM-BEM coupling method.

Below, we refer to some literature that is closely related to the topic of the talk (see also the references cited therein).

References

1. Costabel, M., Symmetric methods for the coupling of finite elements and boundary elements. In Boundary Elements IX, C. Brebbia, W. Wendland, and G. Kuhn (eds.), Springer, Berlin, Heidelberg, New York, 1987, pp. 411–420.

2. Holzer, S. M., Das Symmetrische Randelementverfahren: Numerische Realisierung und Kopplung mit der Finite-Elemente-Methode zur Elastoplastischen Strukturanalyse, Technische Universität München, 1992.

3. Stephan, E. P., Coupling of Boundary Element Methods and Finite Element Methods, Encyclopedia of Computational Mechanics, Vol. 1 Fundamentals, Chapter 13, E. Stein, R. de Borst and T. J. R. Hughes (eds.), John Wiley & Sons, Chichester, 2004, pp. 375-412.

4. Elleithy, W. and Langer, U., Efficient Elasto-Plastic Analysis via an Adaptive Finite Element-Boundary Element Coupling Method, 30. International Conference on Boundary Elements and Other Mesh Reduction Methods (BEM/MRM XXX), Maribor, Slovenia, July 2008, pp. 229-238.

5. Elleithy, W., Analysis of Problems in Elasto-Plasticity via an Adaptive FEM-BEM Coupling Method,Computer Methods in Applied Mechanics and Engineering, in press, doi:10.1016/j.cma.2008.02.018, 2008.

[1] The support of the Austrian Science Fund (FWF), Project number: M950, Lise Meitner Program, is gratefully acknowledged. The authors wish to thank Prof. O. Steinbach, Graz University of Technology, for providing the symmetric Galerkin boundary element computer codes utilized in some parts of this investigation.

The mathematical model of the forward problem of Magnetic Induction Tomography

S. Engleder, O. Steinbach, S. Zaglmayr
TU Graz

Magnetic Induction Tomography is a contactless imaging modality, which aims to obtain the conductivity distribution of the body. The method is based on exciting the body by magnetic induction using an array of transmitting coils to induce eddy currents. A change of the conductivity distribution in the body results in a perturbed magnetic field, which can be measured as a voltage change in the receiving coils. Based on these measurements the conductivity distribution can be reconstructed by solving an inverse problem.
In this talk two models for the corresponding forward problem are presentend. The full model uses the complete set of Maxwell's equations, the reduced model reduces the full model to a Poisson equation. The error between the full and the reduced model is analyzed and some estimates for the error are given. Furthermore the boundary element formulations for both models are discussed and some numerical examples are presented.

Advances in nonlocal electrostatics

C. Fasel[1], S. Rjasanow[1], O. Steinbach[2]
[1]Universität des Saarlandes, Saarbrücken, [2]TU Graz

In contrast to local electrostatics where one usually solves the Poisson equation, nonlocal electrostatics is more complicated. Nonlocal material behaviour occurs, for example, when electric fields in water are observed. The extraordinary behaviour has its origin in the existence of a network of hydrogenbonds inside the water which are on the one hand energetically favourabble for water, and, on the other hand, need some fixed angles between the water molecules. When applying an electric field, the water molecules which are dipoles should orient themselves along the field which would lead to a loss of hydrogenbonds. This results in the end in a shielding effect that depends on the distance from the source of the field. The original model for nonlocal electrostatics (see e.g. [1,2]) involves some differential equations in combination with intergral equations.
We will present an equivalent system of four partial differential equations in each domain (see e.g. [3]). For the spherical symmetric special case of an ion with charge located at the origin, an analytical solution will be given. The problem is an interface problem. The structure of the surface of an biomolecule and its size seem to exclude numerical calculations using finite element methods, and, therefore, we want to use boundary element methods. So we also present a fundamental solution for the operators involved in the PDE-formulation, show their ellipticity and give a boundary integral ial matrices for the operator on the unbounded exterior domain will be discussed. First numerical results will be shown.
In addition to BEM, we also did some first tests using the fundamental solution method. We will discuss advantages and drawbacks of both methods for this problem.

References

1. A. A. Kornyshev, A. I. Rubinshtein, M. A. Vorotyntsev: Model nonlocal electrostatics. J. Phys. C., Solid State Phys. 11 (1978) 3307–3331.

2. A. Hildebrandt, H.–P. Lenhof, R. Blossey, S. Rjasanow, O. Kohlbacher: Electrostatic potentials of proteins in water: A structured continuum approach. Bioinformatics 23 (2007) 99–103.

3. C. Fasel, S. Rjasanow, O. Steinbach: A Boundary Integral Formulation for Nonlocal Electrostatics. In: Numerical Mathematics and Advanced Applications. Proceedings of ENUMATH 2007 (K. Kunisch, G. Of, O. Steinbach eds.), Springer, Heidelberg, pp. 117–124, 2008.

Simple a posteriori error estimators for boundary element methods in 3D

S. Ferraz–Leite, D. Praetorius
TU Wien

As model problem, we consider Symm's integral equation

$$V\phi(x) = \frac{1}{4\pi}\int_\Gamma \frac{1}{|x-y|}\phi(y)\,ds_y = f(y)$$

with weakly-singular integral operator. The h-$h/2$-strategy is one very basic and well-known technique for the a posteriori error estimation. Let ϕ denote the exact solution. One then considers $\eta_H := \|\phi_h - \phi_{h/2}\|$ to estimate the error $\|\phi - \phi_h\|$, where ϕ_h is the Galerkin solution with respect to a mesh $\mathcal{T}_h$ and $\phi_{h/2}$ is the Galerkin solution for a mesh $\mathcal{T}_{h/2}$ obtained from uniform refinement of $\mathcal{T}_h$. We stress that η_H is always efficient $\eta_H \le \|\phi - \phi_h\|$, even with known constant 1. Under the saturation assumption $\|\phi - \phi_{h/2}\| \le q\|\phi - \phi_h\|$ with some constant $q \in (0,1)$ there holds reliability

$$\|\phi - \phi_h\| \le \frac{1}{\sqrt{1-q^2}}\,\eta_H.$$

However, for boundary element methods, the energy norm $\|\cdot\|$ is non-local and thus the error estimator η_H does not provide information for a local mesh-refinement. Recent localization techniques from [1] for $\widetilde{H}^{-\alpha}$-norms allow to replace the energy norm in the case of isotropic mesh-sequences by mesh-size weighted L^2-norms. For instance the L^2-norm based estimator $\mu_H := \|h^{1/2}(\phi_h - \phi_{h/2})\|_{L^2(\Gamma)}$ is equivalent to η_H.

Based on these error estimators we introduce an h-adaptive algorithm. We stress, that convergence of the adaptive scheme has been proven recently under the saturation assumption [3]. Compared to uniform mesh-refinement, the experimental convergence rate is improved by the adaptive algorithm. Nevertheless, we do not observe the optimal order of convergence which is due to the occurrence of edge singularities. We therefore enhance our original algorithm by a heuristic criterion to steer anisotropy. Numerical experiments show that the enhanced algorithm recovers optimal convergence.

References

1. C. Carstensen, D. Praetorius: Averaging techniques for the effective numerical solution of Symm's integral equation of the first kind. SIAM J. Sci. Comp. 27 (2006) 1226–1260.

2. S. Ferraz-Leite, D. Praetorius: Simple a posteriori error estimators for the h-version of the boundary element method. ASC Report 01/2007, Institute for Analysis and Scientific Computing, Vienna University of Technology, Wien, 2007.

3. S. Ferraz-Leite, C. Ortner, D. Praetorius: Adaptive Boundary Element Method: Simple Error Estimators and Convergence. In: Analysis of Boundary Element Method, EMS Publishing House, Oberwolfach Report 19/2008, 2008

Higher-order Whitney forms

M. Fleck
Universität des Saarlandes, Saarbrücken

Whitney forms are widely used for electromagnetic field problems. While it is desirable to have forms of higher polynomial degree, in general these lack some properties of their lower degree cousins. One example, which we investigate, is the precise geometrical localisation of their degrees of freedom (i.e. the coefficients of a linear combination of basis forms) on associated elements inside the mesh.
We discuss a variant of higher-order Whitney forms proposed by Alain Bossavit and make suggestions of how to deal with its difficulties, especially the localisation of degrees of freedom. Furthermore we present a discretisation of the higher-order differential operator which acts directly on degrees of freedom instead of integral values over mesh elements.
Finally we compare some FEM results using first and second order Whitney forms respectively.

References

1. A. Bossavit: Generating Whitney Forms of Polynomial Degree One and Higher. IEEE Transactions on Magnetics, Vol. 38, No. 2, 2002, pp. 341-344
2. F. Rapetti, A. Bossavit: Geometrical localisation of the degrees of freedom for Whitney elements of higher order. IET Sci. Meas. Technol., Vol. 1, No. 1, 2007, pp. 63-66
3. R. Hiptmair: Higher Order Whitney Forms. J. Electr. Waves and Appl., Vol. 15, 2001, pp. 271-299

Modelling the elastic properties of composite materials using BEM

R. Grzibovski
Universität des Saarlandes, Saarbrücken

To determine effective elastic properties of a two-component composite material, an interface problem for the Lamé system is formulated. The problem is then restated in terms of boundary integral equations and a Galerkin BEM is applied for the resulting system. The Adaptive Cross Approxiamtion technique is employed in order to reduce the complexity of the numerical method. In the case when the structure of the composite posesses symmetries, identical blocks in Galerkin matrices can be identified. This leads to an additional reduction of memory requirement for the numerical computaion. Several numerical examples are presented.

GPU Accelerated Algorithms [2]

G. Haase, M. Liebmann
Karl–Franzens–Universität Graz

Recent developments in graphics hardware by NVidia and ATI, and associated software development tools as CUDA enable us to transfer numerical solver components on the recent generation of graphics processing units (GPUs). Although the adaption to the graphics processing unit requires a redesign of the solver components to fit into the highly parallel framework of the GPU, the resulting solver outperforms the fastest single CPU implementation by an order of magnitude. We present the adaption of an algebraic multigrid solver for sparse unstructured system matrices on these GPUs resulting in a performance gain of factor 6–10. Ideas how to use the potential of the GPU for the BEM matrix generation and system solving will be discussed.

[2]This work is supported by the grants for SFB F32 and AustrianGrid 2.

Fast methods for 3D Electric Impedance Tomography

H. Harbrecht
Universität Bonn

In this talk we consider the identification of an obstacle or void of different conductivity included in a three-dimensional domain by measurements of voltage and currents at the boundary. To compute the forward solution operator and its Fréchet derivative we apply a wavelet based boundary element method. Moreover, we discuss the characterization and implementation of the adjoint of the Fréchet derivative. For the solution of the inverse problem we use a regularized Newton method. Numerical examples illustrate the performance of our method.

A hybrid BEM formulation for Surface Acoustic Wave Interdigital transducers modelling

C. Jerez-Hanckes, J. C. Nédélec, V. Laude
Ecole Polytechnique, Palaiseau

In this work, we consider the modelling of Surface Acoustic Wave (SAW) Interdigital transducers (IDT) via a hybrid BEM formulation using spectral and local bases [1,2]. SAW IDTs are ubiquitous components in mobile communication systems and are the subject of intense research for improving design tools. They can be seen as a piezoelectric half-space over which a flat perfectly conducting layer is placed. The metal screen is a smooth orientable bounded manifold $\Gamma \subset \mathbb{R}^2$ lying in $\mathbb{R}^3$ with Lipschitz boundaries, wherein solutions are known to possess singular behaviors. Thus, classical Galerkin or collocation methods have poor convergence. On the other hand, due the extremely elongated form of the structures, even methods mimicking border singularities become impractical. The proposed hybrid element approach overcomes these issues by mixing bases according to the local singular behavior.

References

1. C. Jerez-Hanckes, V. Laude, J.-C. Nédélec, R. Lardat: 3-D Electrostatic hybrid elements model for SAW interdigital transducers. IEEE Trans. Ultrason., Ferroelec., Freq. Control, vol. 55, no. 3, pp. 686–695, 2008.

2. C. Jerez-Hanckes, V. Laude, J.-C. Nédélec, R. Lardat: 3D SAW IDT Boundary Element Model for Massless Electrodes. Proc. IEEE Ultrasonics Symposium, pp. 707–710, 2007.

Optimal shape design for nonlinear axisymmetric magnetostatics using a coupled FEM–BEM scheme

D. Lukas

Technical University of Ostrava

I present an application of optimal shape design of a DC electromagnet. For each design an underlying quasi–linear axisymmetric magnetostatic state problem is solved, while considering Hiptmair's ansatz for the symmetric coupling of FEM and BEM. Assembling the BEM matrices makes use of a Duffy transform and the tensor–product Gaussian quadrature. The nonlinear behaviour of the ferromagnetics is modelled by FEM and it is resolved within Newton iterations. I employ a steepest–descent method with an active set approach for the constrained optimization. Evaluation of shape derivatives is provided by a semi–analytic adjoint sensitivity analysis method, which involves one additional solution to the linearized adjoint state problem.

Aspects of the application of Adaptive Cross Approximation in an elastic Boundary Element formulation

M. Messner, M. Schanz
TU Graz

In order to make the Boundary Element Method more competitive when dealing with problems in elasticity the present work focuses on the adaptive cross approximation (ACA). This method enables the approximation of admissible blocks which are identified a priori by the H-Matrix structure. Its advantage is based on the fact that only a few of the original matrix entries have to be generated. However, problems arise when dealing with vectorial problems, e.g., in elasticity. The extension of the well studied scalar-valued ACA to the resulting matrix-valued ACA is not straightforward. In this work, a repartitioning of the H-Matrix is introduced to allow for a scalar-valued approximation. Special care has to be taken in order to preserve the efficiency of the method. Aspects of this extension will be discussed.

A Skin Effect Approximation for Three-Dimensional Eddy Current Problems

E. P. Stephan, J. E. Ospino
Leibniz University Hannover

We consider the scattering of time periodic electro-magnetic fields by metallic obstacles, the eddy current problem. In this interface problem different sets of Maxwell equations must be solved in the obstacle and outside, while the tangential components of both electric and magnetic fields are continuous across the obstacle surface. We develop an asymptotic procedure which applies for large conductivity and reflects the skin effect in metals. The key to our method is to introduce a special integral equation procedure (see [1]) for the exterior boundary value problem corresponding to perfect conductors. The asymptotic procedure gives a great reduction in complexity of solution since it involves solving only the exterior boundary value problem. In this paper we extend our procedure from the two-dimensional case in [2] to three dimensions.

References

1. R. C. MacCamy, E. P. Stephan: Solution Procedures for Three-Dimensional Eddy Current Problems. J. Math. Anal. Appl. 101 (1984) 348–379.
2. R. C. MacCamy, E. P. Stephan: A Skin Effect Approximation for Eddy Current Problems. Archive for Rational Mechanics and Analysis 90 (1985) 87–98.

Impact of basis functions in BEM (FEM) calculation of eddy–current problems

Z. Andjelic, D. Pusch

ABB Corporate Research Switzerland

In this talk we discuss briefly the impact of the order of the shape functions when calculating eddy–current problems using FEM or BEM. The considered model geometry is given by the TEAM benchmark family P21. Several numerical results are given for constant/linear/quadratic basis functions, for both finite and boundary element code. The comparison suggests the appropriate choice of the order of the shape functions with respect field penetration depth and corresponding mesh discretization.

Mixed Finite Element/Boundary Element Coupling for the Two-Dimensional Exterior Stokes Problem

A. Radcliffe
Leibniz Universität Hannover

A hybrid mixed finite element / boundary integral method is presented for the primative variable formulation of the two-dimensional steady state exterior Stokes' problem. The prognostic velocity and pressure variables are supported in the exterior region with both single and double layer hydrodynamic potentials allowing a symmetric, well conditioned, matrix structure for the velocity boundary integral equation (VBIE) with a simple regularisation of the hyper-singular integrals for the velocity through a repeated integration by parts.
The hyper-singular integral arising in the associated pressure boundary integral equation (PBIE), where the integral kernals have singularities an order higher than in the VBIE, is regularised using a simple solution technique.
To accomodate the Babuska-Brezzi, or "inf-sup", condition in the interior region, the velocity and pressure are modelled with a selection of different Lagrangian finite element pairs, using both pressure corrections (where required) and mixed element orders for the discretised velocity and pressure unknowns, yielding an indefinite system for the interior which when coupled with the boundary integral matrices for the exterior results in a multiple saddle point problem.

Hierarchical surface mesh generation for Wavelet BEM solvers

M. Radrainarivony
Universität Bonn

We report on our results on surface mesh generation from CAD models. Our method is featured by its ability of generating hierarchical meshes which are very useful for solvers requiring nested trial spaces. To construct wavelets on manifolds the parametric description of the boundary surface is needed.
We need to decompose the boundary of a solid into four-sided patches F_i such that there is a regular mapping γ_i from the unit square to each F_i. Since we use Coons functions to generate the mappings γ_i, all curves are parametrized in arc length so that the functions γ_i match well at surface joints. That result is valid for any blending functions of the Coons patches. We use a reparametrization approach which keeps the shape of the initial curves while achieving arc length parametrization.
The decomposition techniques are applied to real CAD data which come from IGES files. Comments about generalization into 3D solid meshes are provided.

Spectral Fourier methods with projectors of the Calderón type for surface plasmon polaritons enhanced nanostructures[3]

L. Raguin, C. Hafner, R. Hiptmair, R. Vahldieck
ETH Zürich

The development of numerical simulation algorithms to study nanostructures for applications ranging from single-molecule sensing at visible frequencies to cancer therapy in near infrared has attracted a considerable amount of research interest. It is fuelled by the desire of device miniaturization exploiting plasmonic effects in metallic particles which are much smaller than the excitation wavelength. In such a case the response of metals is quite different from the metallic conductivity observed at lower frequencies. It leads to solving the Maxwell's equations with material properties presented at the nanoscale by complex valued frequency dependent dielectric permittivities. Despite the linearity of materials, accurate numerical study of plasmonic nanostructures without an extremely fast and efficient numerical algorithm is not feasible even with modern computing hardware for geometrically simple two-dimensional problems. First, the impact of the material dispersion is so dramatic that the nanostructure characteristics can not be scaled to operate at different wavelength. Then the problem must be solved over the whole range of excitation wavelengths taking into account highly accurate dispersion models [2]. Second, the energy of plasmon modes is localized so strongly that the near-field amplitude enhancements might reach several hundred times that of the illumination having fast decay inside the particle [1, 2]. Due to the nature of plasmonic effects the algorithms based on Boundary Integral Equations (BIE) demonstrated to be more promising [2] than those based on Finite Difference and Finite Element Methods. It is caused by the advantage of using the radiating Green function for the exterior field representation avoiding the errors caused by absorbing boundary conditions. In addition, instead of the domain fields only the field components along the boundaries are calculated [1]. Spectral Fourier-Galerkin discretization with Singularity Subtraction [2] has been found to be particularly well suited to convert the BIE into a matrix equation due to smooth regular shapes of nanoparticles. It permits the extensive use of FFT in order to obtain the solution with spectral accuracy, reduced complexity and calculation time while dealing with challenging problems of plasmonics. Although theoretically any BIE formulation based on layer potential technique, including both direct and indirect approaches [3], may appear efficient to solve such an electromagnetic transmission problem [4], in nanoengineering mostly indirect approaches based on the field representation in terms of single-layer potentials [2] are applied to calculate the interior and exterior magnetic fields and their normal derivatives (traces). It was demonstrated in [1] that the algorithm based on Stratton-Chu formulation is more efficient because the tangential components of both electric and magnetic fields may be calculated simultaneously. On the other hand, in most of the experiments at nanoscale only the scattered exterior fields are analyzed. Therefore the formulations based on the boundary-integral projectors of Calderón type [3] may become highly competitive with the BIE formulations used

[3]This work is supported financially by Swiss National Science Foundation project no. 200021-119976 "Spectral Galerkin Boundary Integral Equaiton methods for plasmonic nanostructures".

in [1, 2] because both interior and exterior traces may be expressed in terms of the traces of the scattered exterior field relating them to the traces of the source field. The goal of this work is to investigate spectral Fourier-Galerkin methods based on various BIE formulations to solve transmission problem for the Helmholtz equation in order to select that which is the most efficient to study new phenomena of nanoscale electromagnetics.

References

1. Liaw, J.-W.: Simulation of surface plasmon resonance of metallic nanoparticles by the boundary-element method. J. Opt. Soc. Am. A 23 (2006) 108–116.

2. Raguin, L., Smajic, J., Mishrikey, M., Hafner, C.: Improved performance of numerical algorithms for nanoscale electromagnetics. Proc. SPIE 7100A, 7100A-7, 2008.

3. Nédélec, J.-C.: Acoustic and electromagnetic equations. Springer-Verlag, New York, 2001.

4. Kress, R., Roach, G. F.: Transmission problems for the Helmholtz equation. J. Math. Phys. 19 (1978) 1433–1437.

Analytical integrations in 3D BEM for hyperbolic problems

A. Salvadori, A. Temponi
Università di Brescia

Some results on the analytical integration of kernels in hyperbolic problems (acoustics, elastodynamics) for 3D Boundary Element Methods are presented. Adopting polynomial shape functions of arbitrary degree (in space and time) on flat discretizations, integrations are performed both in space and time for Lebesgue integrals working in a local coordinate system. For singular integrals, both a limit to the boundary as well as the finite part of Hadamard approach have been pursued. Computational remarks and issues are addressed.

An Adaptive Fast Multipole Method for the Rapid Solution of the Stationary Linearized Navier-Stokes System

T. S. Samrowski

Fraunhofer Institute for Scientific Computing and Algorithms, Sankt Augustin

The application of an adaptive version of the fast multipole method (FMM) of Greengard and Rokhlin for the stationary linearized Navier-Stokes system in the two-dimensional case will be presented. FMM is one of the most efficient methods to compute matrix-vector multiplications and hence accelerates the resolution of linear equation systems. Here an algorithm for the evaluation of hydrodynamical potentials with the almost linear computational complexity will be described. For this purpose the complex representation of the hydrodynamical potentials as well as the statements about the corresponding multipole and local expansions, translation, rotation and conversion operators will be given. The numerical experiments we present confirm the theoretical statements.

Modelling of poroelastic materials

M. Schanz, O. Steinbach, P. Urthaler
TU Graz

Wave propagation in porous media is an important topic for example in geomechanics or oil-industry. Assuming a geometrically linear description (small displacement and small deformation gradients) and linear constitutive equations (Hooke's law) the governing equations are derived for Biot's theory. The primary unknowns are solid displacement and the pore pressure. This approach is only possible in the Laplace domain. The resulting saddle point problem and simplifications of the system are analyzed. For a semi-infinite homogeneous poroelastic domain a boundary integral formulation is given.

The Gauss Problem

G. Of[1], W. L. Wendland[2], N. Zorii[3]
[1]TU Graz, [2]Universität Stuttgart, [3]National Academy of Sciences of Ukraine

The Gauss problem for condensers is a classical nonlinear variational problem stated by C. F. Gauss himself which became a central issue in abstract potential theory. In this short lecture we present the first results on the application of the multipole method for computing the solution to the Gauss problem on a compact condenser $A = A_1 \cup A_2$ consisting of two separated compact and piecewise smooth two–dimensional surfaces $A_1, A_2 \subset \mathbb{R}^3$. On A we consider charges given by measures

$$\mathcal{M}(A) := \{\mu = \sum_{j=1}^{2} (\text{sign } A_j)\mu^j \quad \text{and} \quad \mu^j \in \mathcal{M}^+(A_j),\ j = 1,2\}$$

where sign $A_j := (-1)^j$ and $\mathcal{M}^+$ are the nonnegative measures. The Gauss problem reads: *Find the equilibrium state* $\mu_0 \in \mathcal{M}(A,a,g)$ *where*

$$\begin{aligned}&\int_A \int_A \frac{d\mu_0(x)d\mu_0(y)}{|x-y|} - 2\int_A f(x)d\mu_0(x)\\ &\quad = \inf_{\mu\in\mathcal{M}(A,a,g)} \Big\{ \int_A\int_A \frac{d\mu(x)d\mu(y)}{|x-y|} - 2\int_A f(x)d\mu(x)\Big\} =: I_0\,.\end{aligned}$$

The set of admissible measures is given by:

$$\mathcal{M}(A,a,g) := \{\mu \in \mathcal{M}(A) \text{ with } \int_{A_j} g\, d\mu^j = a_j,\ j=1,2\}\,.$$

Here g is a given positive, continuous function on A, and a_1, a_2 are two given positive constants. Hence, $\mathcal{M}(A,a,g)$ is an affine cone of measures.
For a compact condenser, this problem is uniquely solvable, and for $f \in H^{1/2}(A)$ and $g \in C^0 \cap H^{1/2}(A)$, the solution has the form

$$\mu_0 = \varphi_0 ds_A$$

with $\varphi_0 \in H^{-1/2}(A)$, $\varphi_0 \geq 0$ and ds_A the surface measure. Therefore, the Gauss problem can be reduced to the case of finding $\varphi_0 \in H^{-1/2}(A)$ as the minimizer of

$$(V\varphi,\varphi)_{L^2(A)} - 2(f,\varphi)_{L^2(A)}$$

on $\varphi \in H^{-1/2}(A)$ with $\varphi = \sum\limits_{j=2}^{2} (-1)^j \varphi^j$ and $\varphi^j \geq 0$ with $\int\limits_{A_j} \varphi^j ds = a_j$ where V denotes the simple layer boundary integral operator on A.
We approximate the problem by piecewise constant boundary elements φ_h incorporating the side conditions as a penalty term, show very first numerical results and want to discuss the physical relevance of the problem and how to improve the efficiency of the numerical method.

Participants

1. Prof. Dr.–Ing. Zoran Andjelic
   ABB Switzerland Ltd., Corporate Research, CH 5405 Baden–Dättwil
   zoran.andjelic@ch.abb.com
2. Dr. Bernhard Auchmann
   CERN AT/MEL – Electromagnetic Fields, CH 1211 Genf 23
   bernhard.auchmann@cern.ch
3. Dipl.–Ing. Markus Aurada
   Institut für Analysis und Wissenschaftliches Rechnen, TU Wien,
   Wiedner Hauptstrasse 8–10, A 1010 Wien
   aurada@aurora.anum.tuwien.ac.at
4. Prof. Dr. Gernot Beer
   Institut für Baustatik, TU Graz, Lessingstrasse 25, A 8010 Graz
   gernot.beer@tugraz.at
5. Dipl.–Ing. Dominik Brunner
   Institut für Angewandte und Experimentelle Mechanik, Universität Stuttgart,
   Allmandring 5b, D 70569 Stuttgart
   brunner@iam.uni-stuttgart.de
6. Dr. Christian Dünser
   Institut für Baustatik, TU Graz, Lessingstrasse 25, A 8010 Graz
   duenser@tugraz.at
7. Dr. Wael Elleithy
   Institut für Numerische Mathematik, Johannes Kepler Universität Linz,
   Altenberger Strasse 69, A 4040 Linz
   wael.elleithy@numa.uni-linz.ac.at
8. Dipl.–Ing. Sarah Engleder
   Institut für Numerische Mathematik, TU Graz,
   Steyrergasse 30, A 8010 Graz
   sarah.engleder@tugraz.at
9. Prof. Dr. Otto von Estorff
   Institut für Modellierung und Berechnung, TU Hamburg–Harburg,
   Denickestrasse 17, D 21073 Hamburg
   estorff@tu-harburg.de
10. Dipl.–Math. Caroline Fasel
    Fachrichtung Mathematik, Universität des Saarlandes
    Postfach 151150, D 66041 Saarbrücken
    fasel@num.uni-sb.de

11. Dipl.–Ing. Samuel Ferraz–Leite
Institut für Analysis und Wissenschaftliches Rechnen, TU Wien,
Wiedner Hauptstrasse 8–10, A 1040 Wien
samuel.ferraz-leite@tuwien.ac.at

12. Dipl.–Math. Marvin Fleck
Fachrichtung Mathematik, Universität des Saarlandes
Postfach 151150, D 66041 Saarbrücken
fleck@num.uni-sb.de

13. Dr. Richard Grzibovski
Fachrichtung Mathematik, Universität des Saarlandes
Postfach 151150, D 66041 Saarbrücken
richards@num.uni-sb.de

14. Prof. Dr. Gundolf Haase
Institut für Mathematik und Wissenschaftliches Rechnen,
Karl–Franzens Universität Graz, Heinrichstrasse 36, A 8010 Graz
gundolf.haase@uni-graz.at

15. Prof. Dr. Helmut Harbrecht
Institut für Numerische Simulation, Universität Bonn,
Wegelerstr. 6, D 53115 Bonn
harbrecht@ins.uni-bonn.de

16. Dr. Jerez–Hanckes
Seminar für Angewandte Mathematik, ETH Zürich, CH 8092 Zürich
cjerez@sam.math.ethz.ch

17. Dipl.–Ing. Lars Kielhorn
Institut für Baumechanik, TU Graz, Technikerstrasse 4, A 8010 Graz
l.kielhorn@tugraz.at

18. Dr. Wolfgang Kreuzer
Austrian Academy of Sciences, Acoustics Research Institute,
Wohllebengasse 12-14, A 1040 Wien
kreiza@kfs.oeaw.ac.at

19. Prof. Dr. Ulrich Langer
Institut für Numerische Mathematik, Johannes Kepler Universität Linz,
Altenberger Strasse 69, A 4040 Linz
ulanger@numa.uni-linz.ac.at

20. Dr. Dalibor Lukas
Department of Applied Mathematics, Faculty of Electrical Engineering and Informatics, VSB – Technical University of Ostrava, Trida 17, listopadu 15, CZ 708 33 Ostrava-Poruba
dalibor.lukas@vsb.cz

21. Prof. Dr. Markus Melenk
Institut für Analysis und Scientific Computing, TU Wien,
Wiedner Hauptstrasse 8–10, A 1040 Wien
melenk@tuwien.ac.at

22. Dipl.–Ing. Matthias Messner
Institut für Baumechanik, TU Graz, Technikerstrasse 4, A 8010 Graz
m.messner@tugraz.at

23. Dipl.–Ing. Michael Messner
Institut für Baumechanik, TU Graz, Technikerstrasse 4, A 8010 Graz
michael.messner@tugraz.at

24. Dr. Günther Of
Institut für Numerische Mathematik, TU Graz,
Steyrergasse 30, A 8010 Graz
of@tugraz.at

25. Jorge E. Ospino, M. Sc.
Institut für Angewandte Mathematik, Leibniz Universität Hannover,
Am Welfengarten 1, D 30167 Hannover
ospino@ifam.uni-hannover.de

26. Dr. Jörg Ostrowski
ABB Switzerland Ltd., Corporate Research, CH 5405 Baden–Dättwil
joerg.ostrowski@ch.abb.com

27. Prof. Dr. Dirk Praetorius
Institut für Analysis und Wissenschaftliches Rechnen, TU Wien,
Wiedner Hauptstrasse 8–10, A 1040 Wien
dirk.praetorius@tuwien.ac.at

28. Dipl.–Ing. David Pusch
ABB Switzerland Ltd., Corporate Research, CH 5405 Baden–Dättwil
david.pusch@ch.abb.com

29. Dr. Alastair Radcliffe
Institut für Angewandte Mathematik, Leibniz Universität Hannover, Am Welfengarten 1, D 30167 Hannover
radcliffe@ifam.uni-hannover.de

30. Dr. Maharavo Radrainarivony
Institut für Numerische Simulation, Universität Bonn,
Wegelerstr. 6, D 53115 Bonn
randrianarivony@ins.uni-bonn.de

31. Ludmila Raguin
Seminar für Angewandte Mathematik, ETH Zürich
mila.raguin@ifh.ee.ethz.ch

32. Prof. Dr. Rjasanow
Fachrichtung Mathematik, Universität des Saarlandes
Postfach 151150, D 66041 Saarbrücken
rjasanow@num.uni-sb.de

33. Isabella Roth
Institut für Analysis und Wissenschaftliches Rechnen, TU Wien,
Wiedner Hauptstrasse 8–10, A 1040 Wien
isabella.roth@tuwien.ac.at

34. Dr. Thomas Rüberg
Institut für Baustatik, TU Graz, Lessingstrasse 25, A 8010 Graz
rueberg@tugraz.at

35. Dr. Stephan Russenschuck
CERN AT/MEL – Electromagnetic Fields, CH 1211 Genf 23
stephan.russenschuck@cern.ch

36. Prof. Dr. Alberto Salvadori
Dipartimento di Ingegneria Civile, Facolta di Ingegneria,
Universita di Brescia, via Branze 43, I 25123 Brescia
alberto.salvadori@ing.unibs.it

37. Dr. Tatiana S. Samrowski
Fraunhofer Institute for Scientific Computing and Algorithms SCAI
Schloss Birlinghoven, D 53754 Sankt Augustin
Tatiana.Samrowski@scai.fraunhofer.de

38. Prof. Dr. Martin Schanz
Institut für Baumechanik, TU Graz,
Technikerstrasse 4, A 8010 Graz
m.schanz@tugraz.at

39. Bernd Schneider
Institut für Numerische Mathematik, TU Graz,
Steyrergasse 30, A 8010 Graz
bernd1@sbox.tugraz.at

40. Prof. Dr. Olaf Steinbach
Institut für Numerische Mathematik, TU Graz,
Steyrergasse 30, A 8010 Graz
o.steinbach@tugraz.at

41. Dipl.–Ing. Peter Urthaler
Institut für Numerische Mathematik, TU Graz,
Steyrergasse 30, A 8010 Graz
urthaler@tugraz.at

42. Prof. Dr.–Ing. Dr. h.c. Wolfgang L. Wendland
Institut für Angewandte Analysis und Numerische Simulation,
Universität Stuttgart, Pfaffenwaldring 57, D 70569 Stuttgart
wolfgang.wendland@mathematik.uni-stuttgart.de

43. Dr. Sabine Zaglmayr
Institut für Numerische Mathematik, TU Graz,
Steyrergasse 30, A 8010 Graz
sabine.zaglmayr@tugraz.at

44. Dipl.–Ing. Jürgen Zechner
Institut für Baustatik, TU Graz, Lessingstrasse 25, A 8010 Graz
juergen.zechner@tugraz.at

45. Prof. Dr. Nataliia Zorii
Institute of Mathematics, National Academy of Sciences of Ukraine, Kiev
natalia.zorii@gmail.com

Erschienene Preprints ab Nummer 2006/1

2006/1	S. Engleder, O. Steinbach: Modified Boundary Integral Formulations for the Helmholtz Equation.
2006/2	O. Steinbach (ed.): 2nd Austrian Numerical Analysis Day. Book of Abstracts.
2006/3	B. Muth, G. Of, P. Eberhard, O. Steinbach: Collision Detection for Complicated Polyhedra Using the Fast Multipole Method of Ray Crossing.
2006/4	G. Of, B. Schneider: Numerical Tests for the Recovery of the Gravity Field by Fast Boundary Element Methods.
2006/5	U. Langer, O. Steinbach, W. L. Wendland (eds.): 4th Workshop on Fast Boundary Element Methods in Industrial Applications. Book of Abstracts.
2006/6	O. Steinbach (ed.): Jahresbericht 2005/2006.
2006/7	G. Of: The All–floating BETI Method: Numerical Results.
2006/8	P. Urthaler, G. Of, O. Steinbach: Automatische Positionierung von FEM–Netzen.
2006/9	O. Steinbach: Challenges and Applications of Boundary Element Domain Decomposition Methods.
2006/10	S. Engleder: Stabilisierte Randintegralgleichungen für äussere Randwertprobleme der Helmholtz–Gleichung
2007/1	M. Windisch: Modifizierte Randintegralgleichungen für elektromagnetische Streuprobleme.
2007/2	M. Kaltenbacher, G. Of, O. Steinbach: Fast Multipole Boundary Element Method for Electrostatic Field Computations.
2007/3	G. Of, A. Schwaigkofler, O. Steinbach: Boundary integral equation methods for inverse problems in electrical engineering.
2007/4	S. Engleder, O. Steinbach: Stabilized Boundary Element Methods for Exterior Helmholtz Problems
2007/5	O. Steinbach, G. Unger: A Boundary Element Method for the Dirichlet Eigenvalue Problem of the Laplace Operator
2007/6	O. Steinbach, M. Windisch: Modified combined field integral equations for electromagnetic scattering
2007/7	S. Gemmrich, N. Nigam, O. Steinbach: Boundary Integral Equations for the Laplace–Beltrami Operator.
2007/8	G. Of: An efficient algebraic multigrid preconditioner for a fast multipole boundary element method.
2007/9	O. Steinbach (ed.): Jahresbericht 2006/2007.
2007/10	U. Langer, O. Steinbach, W. L. Wendland (eds.): 5th Workshop on Fast Boundary Element Methods in Industrial Applications. Book of Abstracts.
2008/1	P. Urthaler: Schnelle Auswertung von Volumenpotentialen in der Randelementmethode.
2008/2	O. Steinbach (ed.): Workshop on Numerical Simulation of the Maxwell equations. Book of Abstracts.
2008/3	G. Of, O. Steinbach, P. Urthaler: Fast evaluation of Newton potentials in the boundary element method.