Proseminar Autumn Semester 2010

Boundary Element Methods for Wave Scattering Numerical Analysis Seminar

Lecturers	:	**Prof. Dr. Ralf Hiptmair**
	:	**Dr. Carlos Jerez-Hanckes**
Venue	:	**LFW E 13**
Time	:	**Thu 15:15–17:00**
First session	:	**12.10.2009**
Prep meeting	:	**Thu 23.09.2010, 15:15, LFW E 13**
Contact	:	**cjerez@sam.math.ethz.ch**
Advisory	:	**Dr. Carlos Jerez-Hanckes, HG G 53.1, Tue, Wed & Thu 10:00-12:00 (upon previous appointment)**
Prerequisites	:	**Knowledge of calculus and numerical methods**
Audience	:	**BSc/MSc Mathematics & Physics, RW/CSE, from the 3rd year**

Description

We will discuss theoretical and practical issues concerning the modeling of wave propagation in unbounded domains via of boundary element or Green's function methods. In particular, we will focus on the Helmholtz equation in $\mathbb{R}^d$, $d = 2, 3$ recurring in the modeling of Acoustics, Elasticity and Electromagnetism.

Presentations

- The seminar will comprise up to 9 student **presentations** of a duration of about 60 minutes.
- Presentations should be prepared using the BEAMER LaTeXpackage (or LaTeXbased tools under MacOS).
- Speakers are advised to elaborate technical manipulations and proofs on the blackboard.
- MATLAB demonstration of simple numerical experiments is expected whenever appropriate.
- The lecture slides in PDF format should be made available immediately after the presentation.
- Advice on scope, depth and form will be given according to the topics selected (see below).

Available topics (*tentative*)

1. Sobolev spaces, trace spaces, Green's theorems, existence and uniqueness of solutions for the exterior Helmholtz equation [10, Sections 2.3–2.6,2.10.2], [12, Sections 2.2–2.5],[9, Chapter 3];
2. Fundamental solutions Integral representation formula, Newton potential, single and double layer potentials, boundary integral operators, Calderón projectors [10, Sections 3.1–3.3,3.6], [12, Sections 6.1–6.6], [9, Chapters 6-7];
3. Integral equation for the Helmholtz problem, Poincaré-Steklov operator [10, Sections 3.4,3.7–3.9], [12, Sections 6.9,7.6],[9, Chapter 9];
4. Boundary Element Method: approximation bases, convergence analyses [10, Chapter 4], [12, Chapters 10,12];
5. Matrix construction: computation of singular integral contributions [10, Chapter 5], [3];
6. Solving the linear system: GMRES [10, Chapter 5], [12, Sections 13.2], Calderón preconditioning [1, 6];
7. FEM-BEM coupling [8, 11];
8. Fast-Multipole Methods [2, 4],
9. Hierarchical Cluster methods [10, Chapter 7], [12, Chapter 14];
10. BEM applied to non-overlapping domain decomposition methods [7, 5], [12, Chapter 15];

Dates for presentations

Date	Speaker	Topic
7.10.2009		
14.10.2009		
21.10.2009		
28.10.2009		
4.11.2009		
11.11.2009		
18.11.2009		
25.11.2009		
2.12.2009		

References

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[2] R. Beatson and L. Greengard. A short course on fast multipole methods. In M. Ainsworth, K. Levesley, M. Marletta, and W. Light, editors, *Wavelets, Multilevel Methods and Elliptic PDEs*, Numerical Mathematics and Scientific Computation, pages 1–38. Clarendon Press, Oxford, 1997.

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[5] G. Haase, B. Heise, M. Kuhn, and U. Langer. Adaptive domain decomposition methods for finite and boundary element equations. In W. Wendland, editor, *Boundary element topics. Proceedings of the final conference of the priority research programme "Boundary Element Methods" 1989-1995 of the German Research Foundation, October 2–4, 1995 in Stuttgart, Germany*, pages 121–147. Springer, Berlin, 1997.

[6] R. Hiptmair. Operator preconditioning. *Computers and Mathematics with Applications*, 52(5):699–706, 2006.

[7] G. Hsiao and W. Wendland. Domain decomposition in boundary element methods. In R. Glowinski, Y. Kuznetsov, G. Meurant, J. Périaux, and O. Widlund, editors, *Fourth International Symposium on Domain Decomposition Methods for Partial Differential Equations*, pages 41–49. SIAM Philadelphia, 1991.

[8] C. Johnson and J. Nédélec. On the coupling of boundary integral and finite element methods. *Math. Comp.*, 35(152), 1980.

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[11] F.-J. Sayas. The validity of Johnson-Nédélec's BEM-FEM coupling on polygonal interfaces. *SIAM J. Math. Anal.*, 47:3451–3463, 2009.

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