Project: (version of January 17, 2012)

Preconditioned Boundary Element Methods for Electromagnetic Scattering at Dielectric Objects

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Funding: Grant from Thales SA (awarded in 2008, CHF 318'000)
Duration: ongoing, started in September 2008

The project targets the scattering of time-harmonic electromagnetic waves at dielectric objects. Low and medium frequencies are considered. The objects are composed of several homogeneous linear materials with different electromagnetic properties. The goal is to design fast numerical simulation methods based on direct boundary integral equation formulations and Galerkin boundary element discretization.

For three-dimensional problems the use of matrix compression techniques (fast multipole method) becomes mandatory. This enforces the iterative solution of the compressed discrete boundary integral equations. To curb the number of iterations one may either use inherently well condition boundary integral equations (of the second kind) or resort to preconditioning. The latter approach can rely on either the operator preconditioning technique or multilevel preconditioning based on wavelet bases.

Results.

- A novel so-called local multi-trace boundary integral equation formulation could be established and analyzed rigorously. It is amenable to local preconditioning.
- Different variants of a new second-kind formulation was derived, which is intrinsically well-conditioned.
- From the classical single trace integral equations a new global multi-trace formulation was obtained by means of a limiting procedure. Its rigorous theoretical justification was carried out for both acoustic and electromagnetic scattering.

Publications resulting from the project

[1] X. Claeys, *A single trace integral formulation of the second kind for acoustic scattering*, Research Report 2011-15, SAM, ETH Zürich, Zürich, Switzerland, 2011.

[2] X. Claeys and R. Hiptmair, *Boundary integral formulation of the first kind for acoustic scattering by composite structures*, Report 2011-45, SAM, ETH Zürich, Zurich, Switzerland, 2011. Submitted to Comm. Pure Applied Math.

[3] ——, *Electromagnetic scattering at composite objects: A novel multi-trace boundary integral formulation*, Report 2011-58, SAM, ETH Zürich, Zürich, Switerland, 2011. Submitted to M2AN.

[4] R. Hiptmair and C. Jerez-Hanckes, *Multiple traces boundary integral formulation for Helmholtz transmission problems*, Adv. Appl. Math., (2011). Published electronically.