Internship for Master 2
in Applied Mathematics

Fast block sparse solvers for boundary integral formulations of wave propagation

Context This internship oriented toward computational mathematics will focus on fast block sparse solvers in the context of scalar wave propagation. Even in the context of high performance computing, it remains challenging to propose efficient solvers for high or even moderate frequency propagation problems. In the case of piecewise homogeneous propagation media, a natural idea consists in using boundary integral formulation of the problem.

Boundary integral formulations consist in rewriting (a priori) volumic PDEs as equivalent equations posed only on the boundary of the computational domain. Although more complicated than volumic formulations of PDEs, integral formulations give rise to much less dispersive numerical methods. This approach transforms a large sparse 3D problem into a 2D dense one.

This kind of technique is of particular interest in electrical engineering for the design of antenna systems where electromagnetic wave propagation is to be considered. This will be the actual application context of this internship.

Objectives The goal of this internship is a numerical investigation of modern compression techniques such as multipoles or adaptative cross approximation for devising fast block sparse solvers for the so-called local multi-trace boundary integral formulations introduced in [2]. The internship will start with a bibliographical work on boundary integral formulations of harmonic wave propagation and fast linear solvers. Starting from preliminary results obtained in our group, the candidate will implement a numerical code for testing compression techniques applied to sparse solvers that exploit strong algebraic identities of multi-trace integral operators. He will evaluate the performance of the solvers comparing with existing approaches.

Candidate profile The candidate should have strong programming skills in a scientific computing language (FORTRAN, C, C++), and a solid theoretical background on the numerical analysis of elliptic PDEs (variational theory of the laplacian, Lax-Milgram theorem, finite element method).

Possible continuation of this work as a Ph.D. thesis funded by ICS (Institut du Calcul Scientique) on computational mathematics and high performance computing. Hence, a first experience in high performance/parallel computing would be greatly appreciated.

Practical information

Location: Jacques-Louis Lions Laboratory, Univ. Paris 6.
Duration: 5 month.

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References

[1] S.Sauter & C.Schwab, *Boundary element methods*, Springer Series in Computational Mathematics, 39. Springer-Verlag, Berlin, 2011.

[2] R. Hiptmair & C. Jerez-Hanckes, *Multiple traces boundary integral formulation for Helmholtz transmission problems*, *Adv. Comput. Math.*, 37(1):39–91, 2012.