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Domain Embedding/Controllability Methods for the Conjugate Gradient Solution of Wave Propagation Problems: Application to Shape Optimization

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Abstract: The main goal of this paper is to discuss the numerical simulation of propagation phenomena for time harmonic electromagnetic waves by methods combining controllability and fictitious domain technologies.
The method relies on :

1. distributed Lagrangian multipliers, which allow the propagation to be simulated on an obstacle free computational region using regular finite element meshes essentially independent of the geometry of the obstacle;

2. a controllability formulation which leads to conjugate gradient algorithms with good convergence properties to time-periodic solutions.

This novel methodology has been validated by the solutions of test cases associated to non trivial geometries, possibly non-convex. The numerical experiments show that the new method performs as well as the method discussed in [ref.1] where obstacle fitted meshes were used.
We shall conclude this presentation by describing the results of a shape optimization problem consisting in the RCS minimization of aerodynamic obstacles where the above simulator is coupled with Evolutionary Algorithms [ref. 2].

[1] M.O. Bristeau, R. Glowinski, J. Periaux, *Controllability methods for the computation of time periodic solutions; applications to scattering*, Journal of Computational Physics, 147, 1998, pp: 265-292.

[2] R.A.E. Makinen, J. Periaux and J. Toivanen, *Multidisciplinary shape optimization in aerodynamics and electromagnetics using Genetic Algorithms*, in Int. J. Numer. Meth. Fluids 30: 149-159 , 1999.

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