EFIE, MFIE, and CFIE Solutions of Electromagnetic Scattering Problems

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In our pursuit to solve increasingly larger computational electromagnetics problems, we have been enjoying the efficiency and power of the fast multipole method (FMM) and the multi-level version thereof, i.e., the multi-level fast multipole algorithm (MLFMA). Since the MLFMA (and also the FMM) is an iterative technique, it is imperative to keep the number of iterations as low as possible for any given problem. As with any iterative solution, the number of iterations naturally depends on the choices of the iterative solver, the preconditioner, and the initial guess. In addition, the number of iterations also depends on the underlying features of the matrix equation to be solved. These features are determined by numerous other choices, such as the analytical formulation method (e.g., surface or volume formulation, the use of electric-field, magnetic-field, or combined-field boundary conditions), representation of the problem geometry (e.g., open or closed surfaces, sharp edges, thin structures, order of approximation), and the discretization method (e.g., fineness of the mesh, choice of the basis and testing functions).

In addition to the multitude of the above parameters, the task of reducing the number of iterations is further complicated by the interdependence of those parameters. For example, using EFIE (electric-field integral equation) with no preconditioner is a straightforward choice, however, its convergence depends on the type and size of the problem. To improve the convergence properties, either a preconditioner or a CFIE (combined-field integral equation) formulation or both can be used. On the other hand, more successful preconditioners are usually more difficult to parallelize and the CFIE requires MFIE (magnetic-field integral equation), which has the drawbacks of not being suitable for geometrics with open surfaces and degraded accuracy compared to EFIE.

In this talk, an overview of our efforts to reduce the number of iterations will be presented within the context of EFIE, MFIE, and CFIE. Furthermore, the effects of various iterative solvers and preconditioners on the iteration counts will also be addressed. Finally, the role that basis and testing functions are playing on the accuracy of the MFIE will be commented on.

Special Session: "Integral-Equation Methods"
Session Organizer: Dr. Levent Gürel and Dr. Jin-Fa Lee

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