Fast High-Order Solutions for Electromagnetic Scattering from Three-Dimensional Bodies

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Recent advances in the development of computational methods have made it feasible to obtain fast and accurate solutions for electromagnetic scattering from composite scatterers. The multilevel fast multipole method (MLFMA) is an $O(N \log N)$ algorithm used for reducing the computational complexity of integral equation-based methods. Using computers commonly available today, this method can be employed to solve large problems in the range of hundreds of thousands of unknowns. The main purpose of this paper is to summarize our research in the developement of fast and accurate scattering solutions for composite scatterers. Towards this purpose, we have developed two sets of higher-order MLFMA solutions. The first set of higher-order solutions are the traditional higher-order solutions employing higher-order forms of Rao-Wilton-Glisson (RWG) basis functions that guarantee the normal continuity of the expanded unknown current density and the Galerkin's method. Consequently, this method can be applied only to well-connected meshes. The second set of solutions are based on a set of novel higher-order basis functions known as the grid-robust basis functions. These basis functions represent the unknown electric current density within each patch using the Lagrange interpolation polynomials. The Lagrange interpolation points are chosen to be the same as the nodes of the higher-order Gaussian quadratures. As a result, the evaluation of the integrals in the method of moments (MoM) is greatly simplified when using point-matching technique. More importantly, these basis functions do not require the side of a triangular patch to be entirely shared by another triangular patch; hence, the resultant MoM is applicable even to defective meshes.

The salient features of the two higher-order, MLFMA solutions can be summarized as following: higher-order basis functions are employed in conjuction with higher-order geometry description, the Poggio-miller-Chang-Harrington-Wu-Tsai (P -MCHW) surface integral formulation is used to handle different dielectric materials, the impedance boundary conditon (IBC) and resisitive sheet condition (RS) are incorporated, the MLFMA solutions are MPI-based implementations and hence capable of working on distributed memory systems, and an highly efficient preconditioner such as an incomplete LU (ILU) preconditoner is interfaced through a standard software package. The higher-order solutions are also applicable to the case when mixed-order basis functions (with low-orders on small patches and high-orders on large patches) are employed.