Sparse Factorization of the Impedance Matrix in an Overlapped Localizing Basis: 3-D Case

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Numerical solutions of surface integral equation formulations of time-harmonic electromagnetic interactions with perfect electric conductors (PECs) require solving linear systems of the form

$$\mathrm{E}^{i} + \mathrm{Z}\,\mathrm{J} = 0, \tag{1}$$

where Z is the N-by-N impedance matrix, the vector J contains the coefficients of the basis functions used to represent the electric currents on the conductor, and the vector E^{i} is determined by samples of an impressed electric field. It has recently been shown for scalar problems in two dimensions that a reduced-complexity, error-controllable direct solution of (1) is obtained by expanding and inverting the impedance matrix in a complete set of nonradiating local-global solution (LOGOS) modes. A nonradiating LOGOS mode consists of an excitation/solution pairing, $(\mathrm{J},\mathrm{E}^{i})$ for which the current and the incident field are both localized to a (usually) small region of a larger simulation domain.

This paper summarizes an improved LOGOS direct solution algorithm for PEC scattering problems in three dimensions. It is shown that the solution algorithm requires approximately $O(N\log N)$ floating point operations to determine an $O(N)$ factored representation of the impedance matrix for electrically small targets. These reduced complexities are obtained by generalizing the definition of nonradiating LOGOS modes such that the localizing current sources are nonzero over a group and its near neighbors. The scattered field generated by these sources is still confined to a single group at a given level of the oct-tree, however. Combining this modified definition of a nonradiating LOGOS mode with previously reported developments yields a factorization algorithm with the indicated complexities.

The numerical examples reported during the presentation will include electrically small and electrically large targets. The examples will demonstrate the computational complexities reported above. It will also be observed that, for electrically larger targets, the performance of the factorization algorithm is still quite good. For example, the complexity of the factored representation scales approximately as $O(N^{1.17})$ for a 24λ -by- 24λ array of PEC patches. Additional examples will be reported during the presentation.