Error Analysis of QR-Decomposition-Based Nondirective Stable Plane Wave MLFMA

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Integral equations can be converted into linear system of equations via the method of moments (MoM), which has a computational complexity of $O(N^2)$ when solved iteratively, where N denotes the number of unknowns. The computational complexity can be reduced to $O(N^{3/2})$ by using the fast multipole method (FMM) and to $O(NlogN)$ via its multilevel version, namely, the multilevel fast multipole algorithm (MLFMA). Therefore, MLFMA is generally accepted as one of the best algorithms in the analysis of scattering and antenna problems. However, structures that contain significantly fine geometrical details cannot be analyzed in an efficient way using MLFMA due to numerical round-off errors. This drawback has been referred to as the low-frequency breakdown of MLFMA and there are various studies available in the literature to treat it. Among them nondirective stable plane wave MLFMA (NSPWMLFMA) is a promising broadband approach due to its error-controllability and diagonal translation matrices. NSPWMLFMA is based on shifting the integration path into complex plane and obtaining stable translations in all directions via QR-decomposition. However, this approach, in particular the QR decomposed part, requires more investigation on the sources of numerical errors that is provided in this work.

In this contribution, we present a comprehensive study on the accuracy of NSPWMLFMA. We consider one-box-buffer scenario with maximum error configuration for the radiating and testing elements as shown in Fig. 1. To do this, multiple sources at the deepest levels with unit strength placed at the vertices, center of the box, and face centers are aggregated, then shifted to the parent level with interpolation, translated at the parent level and finally disaggregated to the lowest levels with anterpolation. Relative error between the NSPWMLFMA results and the free space Green's function is compared at different levels.

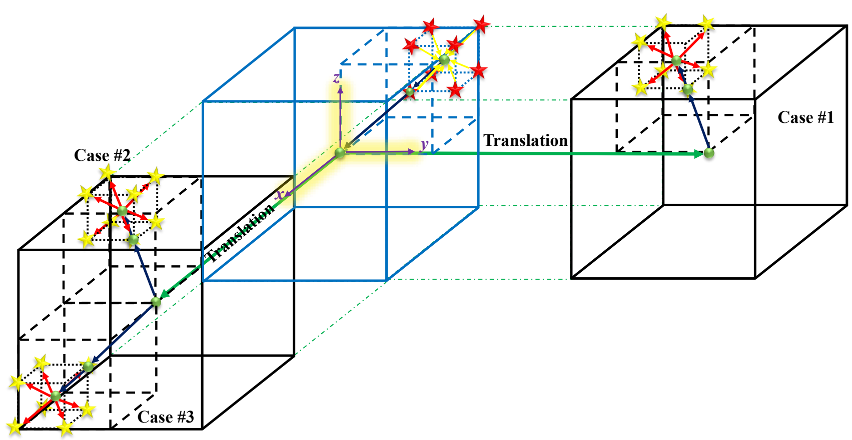

Figure 1: One-box-buffer scenario for testing the accuracy of NSPWMLFMA.