Broadband MLFMA for Electromagnetic Scattering by Dielectric Objects

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In this talk we present a broadband algorithm for the electromagnetic scattering by a homogeneous dielectric object in the 3D space. For handling a large number of unknowns we use a broadband multilevel fast multipole algorithm (MLFMA).

In order to make the iterative solver for MLFMA to converge sufficiently fast, we use a well-conditioned Mueller surface integral equation formulation [1], which provides a broadband formulation for this field problem. One obtains this formulation by writing the EFIE and MFIE equations at both sides (1 and 2) of the surface of the object for the unknowns $\mathbf{J} = \mathbf{n} \times \mathbf{H}$ and $\mathbf{M} = -\mathbf{n} \times \mathbf{E}$, $\mathbf{n}$ being the outer unit normal of the surface, and then combining the equations as

$$-\alpha_1(MFIE_1) + \alpha_2(MFIE_2) \ \text{ and } \ \beta_1(EFIE_1) - \beta_2(EFIE_2)$$

with multipliers $\alpha_j = 2\mu_j/(\mu_1 + \mu_2)$, $\beta_j = 2\epsilon_j/(\epsilon_1 + \epsilon_2)$, $j = 1, 2$.

In our broadband MLFMA [2] we use the traditional MLFMA for levels with division cube sidelength $\geq \lambda/2$, λ being the wavelength, and for levels with smaller cube sidelengths we use an MLFMA based on the spectral representation of the Green's function. In the Mueller formulation the exterior and the interior of the object need MLFMA procedures of their own because they have different wave numbers.

In each iteration step for the matrix-vector product, we need to compute the fields $\mathbf{E}^{\mathbf{sc}}$ and $\mathbf{H}^{\mathbf{sc}}$ due to the given surface currents $\mathbf{J}$ and $\mathbf{M}$. We get the components of the matrix-vector product by adding these currents, multiplied by suitable constants, and by taking inner products with the relevant testing functions.

The outgoing fields are presented by their radiation patterns. For translating the outgoing fields $\mathbf{E}^{\mathbf{sc}}$ and $\mathbf{H}^{\mathbf{sc}}$ from a division cube Q to incoming plane-wave expansions in a non-nearby cube we only need to store the radiation and incoming wave patterns of $\mathbf{E}^{\mathbf{sc}}$, because both $\mathbf{E}^{\mathbf{sc}}$ and$\mathbf{H}^{\mathbf{sc}}$ are obtained directly from them. These patterns are computed easily from $\mathbf{J}$ and $\mathbf{M}$ in Q, and they are stored in three Cartesian components to make the interpolation and anterpolation procedures work in an efficient manner.

We demontrate the resulting broadband MLFMA algorithm by a numerical example, where the bistatic RCS is computed for dielectric spheres with diameters varying from $\lambda/100$ to 3λ and using several levels in MLFMA. A good agreement with the Mie-series results are obtained with reasonable numbers of iterations.

REFERENCES

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2. Wallén, H. and J. Sarvas, *Progress in Electromagnetics Research*, Vol. 55, 47–78, 2005.