A 2D Hybrid Spectral-Integral/Finite-Element Method for Layered Media

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In order to solve problems dealing with electromagnetic scattering from inhomogeneous objects of arbitrary shape embedded in a layered medium, a surface integral equation (SIE) can be combined with other methods such as the finite element method (FEM) in order to account for the inhomogeneity. In this approach, the computational domain can be truncated by using a radiation boundary condition (RBC) such as the hybrid finite element/boundary element method (FEM/BEM), which uses SIE as an RBC on the boundary surrounding the scatterer(s), and FEM in the bounded region.

The matrix size of the FEM problem depends on the accuracy of the basis functions used for both FEM and BEM. The usage of a higher-order method, such as the spectral integral method (SIM) which uses fast Fourier transform (FFT) algorithm to provide exponentially accurate results, can greatly reduce the required sampling density.

Recently, Liu *et al.* propose that the spectral integral method can be utilized as an efficient RBC to truncate the computational domain in the FEM for a homogeneous background medium (J. Liu and Q. H. Liu, submitted for publication). It has been shown that the required number of points on the radiation boundary is only around 5 points per wavelength, thus giving substantial saving in memory and CPU time requirements.

In this work, we extend SIM/FEM to layered-medium problems in two dimensions. The main ingredients of this method are the use of fast Fourier transform (FFT) algorithm and trigonometric interpolation and the subtraction of singularities in Green's functions to achieve a spectral accuracy in the integral. SIM is used as an RBC for the FEM in layered-medium problems which allows the objects inside the surface to be arbitrarily inhomogeneous. The accuracy and efficiency of this hybrid FEM/SIM have been validated with several numerical examples.