FMM Solution of Electromagnetic Scattering Problems Involving Curved Surfaces

Kubilay Sertel and Levent Gürel
Bilkent University
Bilkent, Ankara, Turkey
(lgurel@ee.bilkent.edu.tr)

Real-life electromagnetic scattering problems, almost always, involve electrically large scatterers with complicated geometries. In this work, in order to reduce the geometry-modelling error, exact models and higher-order approximation techniques are used to represent three-dimensional curved surfaces.

Canonical geometries such as spherical, cylindrical and conical surfaces can be exactly modelled. Arbitrarily curved surfaces can be accurately modelled using biquadratic, bicubic or higher-order polynomials. It will be shown that non-uniform rational B-spline (NURBS) surfaces and Bézier patches can also be used for the same purpose. NURBS surfaces are powerful modelling tools that are widely used in computer-aided graphical design (CAGD) applications. Hence, the representations of most bodies fabricated by using automated machining processes are based on NURBS meshes. Therefore, the geometry data output of a CAGD tool can be directly used as the input of our electromagnetic-scattering code.

The basis functions are defined to be conformal with the surface representation and are "curved" generalizations of the piecewise linear basis functions defined on flat rectangular domains (rooftops) and triangular domains (due to Rao, Wilton and Glisson). The flat versions of these basis functions will be compared on the basis of how well the boundary conditions are satisfied on the conducting surfaces of some canonical geometries. Issues concerning the numerical computation of the singular and nonsingular integrals obtained with the aforementioned curved surface representations and basis functions will also be addressed.

The fast multipole method (FMM) will be employed to solve problems involving large scatterers. Both the efficiency and the accuracy of the FMM will be demonstrated by comparing the FMM solutions to the method-of-moments (MoM) and closed-form solutions for some sample problems. It will also be shown that using better geometry models improves the accuracy of the solutions and reduces the size of the resulting matrix equation. Thus, the combination of the FMM and accurate geometry-modelling techniques will be proposed for efficient solution of real-life electromagnetic scattering problems.