Rules for Adoption of Expansion and Integration Orders in Moment-Method Computation of Electromagnetic Scattering and Radiation

Nada J. Šekeljić*[1], Elene Chobanyan[1], Milan M. Ilić[1],[2], and Branislav M. Notaroš[1]
(1) Electrical & Computer Engineering Department, Colorado State University, Fort Collins, CO
(2) School of Electrical Engineering, University of Belgrade, Serbia
inadasek@engr.colostate.edu, sihaia@lamar.colostate.edu, milan.ilic@etf.rs, notaros@colostate.edu

This paper presents results of our continued study of higher order parameters in computational electromagnetics (CEM), in which we investigate and evaluate the behavior of higher order hierarchical CEM numerical solutions to electromagnetic scattering and radiation problems by running an exhaustive series of simulations and systematically varying and studying the key higher order modeling parameters and their influence on the solutions. In particular, we focus here on the method of moments (MoM) to solve surface integral equations for arbitrary metallic and piecewise homogeneous dielectric structures and consider polynomial orders of basis functions (*N*) for expansions of surface electric and magnetic currents in the model and orders of Gauss-Legendre integration formulas – numbers of integration points (*NGL*) used for integrations of potential and field integrals in MoM generalized impedances (matrix elements).

In addition to simulations of several classes of *p*-, *h*-, and *hp*-refined canonical models of cubical and spherical metallic and dielectric scatterers, we present a very extensive numerical analysis and study of the NASA almond, which is an EMCC (Electromagnetic Code Consortium) benchmark target and one of the most popular benchmarking examples for both research and commercial CEM codes, in several frequency ranges. Also, we study higher order modeling parameters in antenna examples. In addition to models composed only from quadrilateral surface elements with isotropic expansion and integration orders and meshes that are refined isotropically in all directions, we present a discussion of situations when the parameters are changed anisotropically along the element edges. In addition to far-field computations, where the radar cross-section (RCS) error is evaluated, we investigate errors in calculations of the near field, current distribution, and antenna impedance. Based on the study, we present general guidelines and quantitative recipes for adoptions of optimal *N* and *NGL* and for various refinements – in a form of a table of parameters, which can readily be implemented in models and simulations. Possible variations of parameter values in far- vs. near-field and RCS vs. antenna-impedance computations are discussed.

The developed sets of rules for adopting the optimal *N* and *NGL* simulation parameters in a typical higher order MoM simulation should be of significant interest and value for MoM practitioners and application engineers using higher order MoM software, and may result in considerable reductions of the overall simulation (modeling plus computation) time. For instance, computations involving unreasonably high or low *N* and *NGL* orders could result in meaningless models and simulations (that often cannot be refined) and/or in an unnecessarily extensive utilization of computational resources (e.g., orders of magnitude longer computational times). The ultimate goal is to reduce the large gap between the rising academic interest in the higher order CEM and its actual usefulness and use in electromagnetics research and engineering applications.