Residual Error Based Mesh Refinement for Surface Integral Equations

J. A. Tobon Vasquez*(1), Z. Peng(2), J. F. Lee(3), G. Vecchi(1), and F. Vipiana(1)
(1) Politecnico di Torino, 10129 Torino, Italy
(2) University of New Mexico, Albuquerque, NM 87131, USA
(3) Ohio State University, Columbus, OH 43210, USA

In the numerical solution of any surface integral equation problem, the infinite dimensional solution space is approximated with a finite dimensional one and, hence, an error is associated to the numerical solution. Even if the numerical system is well conditioned, the solution accuracy is proportional to the mesh fineness. Hence, an open challenge is to discretize the structure under analysis with a mesh able to achieve the desired level of accuracy everywhere. In particular, in the case of real-life multi-scale antenna problems, it is desirable to have the same level of accuracy for both smooth and non-smooth parts, minimizing the total number of mesh cells.

In this contribution, we propose an algorithm able to generate an automatic localized meshing refinement for increasing the accuracy of integral equation solutions, in particular in the case of multi-scale problems. In the proposed algorithm, first the residual error associated to the solution, performed with the initial mesh, is defined, and, then, projected on a space able to give information for the subsequent h-refinement. In a previous work of the authors (J. A. Tobon Vasquez, Z. Peng, J. F. Lee, G. Vecchi, and F. Vipiana, APS 2018), the residual was projected on a set of *half* Rao-Wilton-Glisson (RWG) basis functions defined on a dyadic refined mesh, much finer with respect to the initial mesh. Here, instead, the residual is projected on a set of *standard* RWG basis functions, still defined on a dyadic refined mesh. The use of the standard RWG basis functions simplifies the algorithm implementation, avoiding the application of Discontinuous Galerkin and of the penalty conditions in the method of moments (MoM) matrix evaluation (Z. Peng, K. H. Lim, and J. F. Lee, IEEE Trans. Antennas Propag., vol. 61, pp. 3617– 3628, July 2013). Then, according to the residual error projection, an error map is associated to each cell of the initial mesh. The error values are compared to a chosen threshold, and the cells with an associated error above threshold are dyadically subdivided obtaining an adaptive h-refinement, that is a *non-conformal* mesh. On the obtained non-conformal mesh, standard RWG functions are defined at the different levels of the adaptive h-refinement, taking advantage of the inter-mesh reconstruction relations between dyadically subdivided triangular cells (F. Vipiana, P. Pirinoli, and G. Vecchi, IEEE Trans. Antennas Propag., Vol. 53, No. 7, July 2005, pp. 2247-2258). Finally, the obtained linear system can be solved with usual fast-MoM solvers, such as the Multi-Level Fast Multiple Algorithm (MLFMA), using the Electric Field Integral Equation (EFIE) or the Combined Field Integral Equation (CFIE).

At the conference, the proposed h-refined algorithm will be described in details showing its performance in the case of real-life multi-scale antenna problems.