Comparison of Different Schemes for Dealing with Integral Singularities in Method of Moments

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Surface-integral-equation (SIE) techniques are essential in helping us to obtain accurate solutions of electromagnetic (EM) problems using the method of moments (MoM). Particularly, the difficult-to-compute singular and near-singular potential integrals present in MoM system matrices must be computed accurately to develop numerical codes able to adequately model and predict the EM behavior of analyzed problems.

Until recently, the most common and well-known scheme to evaluate strongly near-singular integrals has been the so-called "singularity subtraction" approach. The idea is to subtract from the integrand terms having the same asymptotic behavior as the integrand at the singularities; then the bounded difference integrand is integrated numerically by standard quadrature rules, and the subtracted singular terms are integrated analytically (see e.g. M. S. Tong et al., IEEE Trans. Antennas Propag., 57, 2009)

An alternative approach, emerging more recently, is the so-called "singularity cancellation" scheme, where instead of subtracting asymptotic singular terms from the integrand, the singularities are cancelled via appropriate variable transformations. Since the quadrature is performed numerically, a singularity cancellation scheme is essentially independent of bases, element shapes and curvature; moreover, essentially arbitrary accuracy is achievable by suitably increasing the quadrature order (see e.g. P. W. Fink et al., IEEE Antennas Wireless Propag. Lett.,. 7, 2008).

This paper is motivated by the lack, to the authors knowledge, of a fair and comprehensive comparison of the two methods. To compare the accuracy of the two described schemes, we examine the $1/R$ and $1/R^2$ singularities present in the MoM discretization of the Electric and Magnetic Field Integral Equations, EFIE and MFIE, respectively. We consider several pairs of source and test triangles in the near field of one another. The numerical integrals are evaluated using different quadrature schemes, including standard Gauss Legendre (GL) schemes. Also considered are different cancellation techniques. As a reference we consider the result obtained using the Double Exponential (DE) scheme (see e.g. A. G. Polimeridis et al., IEEE Trans. Ant. and Propagat., 60, 2012).