On the Charge-Modeling Capabilities of a Class of Current Basis Functions

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Integral-equation solvers of computational electromagnetics rely on the representation of the unknown function (usually a current distribution) in terms of some known basis functions (BFs). Among various possible choices, piecewise linear functions defined on rectangular subdomains (rooftops or RTs) and triangular subdomains (RWGs) are commonly used in the numerical solution of the surface integral equations.

There are several considerations involved in the choice of the right basis and testing functions. Some of these considerations are reported in the literature. In this talk, we advocate one more constraint: the BFs chosen to model the electric current should also support a consistent and valid charge approximation. This is because the charge distribution is inherently and implicitly approximated by the divergences of the current BFs. We analyze a number of different BFs (including the RT and RWG BFs) with respect to how well they model the charge distribution, in addition to the current. This analysis is carried out by the help of the topological properties of open and closed surfaces meshed into networks of triangles and quadrangles. The topological information is used to relate the numbers of degrees of freedom (DoFs) supplied by the current approximation and required by the charge approximation.

The need for current basis functions to properly model the charge distribution is demonstrated by several examples. In some of these examples, the basis functions seem to be perfectly legitimate when only the current distribution is considered, but they fail to deliver a correct solution of the electromagnetic problem since they are not capable of properly modeling the charge distribution on some surfaces.