Rotation of curl-conforming elements for a frequency stable application to the Surface Integral Equation

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Method of Moments (MoM) transforms a functional operator equation into a matrix equation. When the operator is the surface integral, its solution is useful for the study of antenna and scattering problems involving homogeneous objects.

Since the lower-order basis by Rao, Wilton and Glisson, , the complexity of the structures which are common nowadays demands the improvement of both efficiency and safety of the functions bases representing the electromagnetic magnitudes in the numerical methods. It is known the bad behavior of the numerical solution of Maxwell's equations when the frequency tends to zero. This is due to the decoupling of electric and magnetic fields. When the surface integral equation is discretized, the separation of the basis into solenoidal and non solenoidal functions is of importance to address this issue.

Furthermore, in mixed potential integral equation formulations a singular integration must be solved. Conventional methods of extraction or cancellation of the singularity can be algebraically complicated when high order basis functions and curved elements are used.

In the current work, we obtain higher order curved div-conforming basis functions directly from the curl-conforming finite element families by rotation. We take advantage of the these finite elements sharing the bases functions of both complete and mixed orders. The obtained div-conforming elements are curved triangles, hierarchical, nearly orthogonal and isotropic in relation to the vertex. The decomposition of the bases functions space into two subspaces Gradient and Rotational is transform by means of the rotation into Hodge decomposition for surface currents consisting of a subspace of solenoidal functions and a complement of non solenoidal functions. These basis are used to discretize the Electrical Field Integral Equation (EFIE). For addressing the issue of the singular term in the integral equation due to Galerkin function, we use a coordinate transformation from local space to a new space, which introduces trough the Jacobean a term which cancels the singular behavior. The singularity cancellation is carried out directly on the local domain. The procedure is compatible with any order of curvature of the elements and invariant with the order of the bases functions. Some canonical scattering PEC problems are analyzed in order to test the performance of these elements.