Directive Source Integral Equation

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Conventional surface integral equations of computational electromagnetics often use field representations based on almost omnidirectional elemental sources. Discretization of integral equations employing such omnidirectional sources leads to fully populated dense matrices, whose off-diagonal blocks represent strong coupling between distant parts of the problem geometry. This coupling reduces the efficiency of fast iterative solvers and effectively prevents the construction of general fast direct solvers. On the other hand, the combined source integral equation uses elemental Huygens sources, which radiate mainly towards the exterior of the scatterer.

In this work, we propose a directive source integral equation (DSIE) approach to the formulation of the surface integral equations. This approach is aimed at allowing the construction of fast iterative and direct solvers at a price of modifying the Green's function. Such modified Green's function can be viewed as a field of an elemental source in the presence of a shield that largely blocks the radiation in a given angular sector. Specifically, we focus on the problem of scattering by an impenetrable scatterer that is electrically large and "essentially convex". By "essentially convex" we mean that a strictly convex shape can be inscribed in the scatterer such that the minimum distance from any point on the scatterer surface to the convex body is small or comparable to the wavelength. To facilitate construction of fast solvers for such problems, we focus on the construction of an equivalent situation for the exterior region only. In this case, arbitrary physical or equivalent sources can be introduced in the region originally occupied by the scatterer. The field is only required to satisfy the boundary conditions on the surface of the scatterer. With this approach, we can modify the Green's function by adding a radiation shield on an auxiliary surface to reduce the radiation towards the interior of the scatterer, at the expense of complicating the Green's function construction. We propose the use of absorptive radiation shields based on equivalent electric and magnetic currents that are smoothly truncated to be zero outside the region originally occupied by the scatterer. Such auxiliary surface current distribution can be used to obtain almost perfect shade just behind the shield and also to greatly reduce the radiation towards the scatterer interior. It should also be noted that when we construct the equivalence for the exterior region only, the resulting currents differ from the physical ones. Of course, once the problem is solved, the physical currents can be computed via the boundary magnetic field. An application of the DSIE to a problem of scattering from an essentially convex object will be presented.