Applications of the wavefront evolution technique to high-frequency electromagnetic scattering [1]

E. Bleszynski, M. Bleszynski, and T. Jaroszewicz
Monopole Research, Thousand Oaks, CA 91360

We present elements and representative applications of the wavefront (WF) evolution method in describing high-frequency (HF) electromagnetic scattering phenomena. In our approach the WFs (constant phase surfaces) are implemented as well-defined meshed (triangulated) surfaces, orthogonal to rays, the rays being associated with vertices of the mesh. We describe evolution of rays by means of Geometrical Optics and the Uniform Geometrical Theory of Diffraction (UTD), accounting for diffraction processes (the present implementation being limited to edge diffraction on scatterers defined by facetized surfaces). In our implementation, in order to be able to compute diffracted fields with higher accuracy, we use a suitably modified version of UTD, which ensures that the field behavior near diffraction edges is reproduced in agreement with the exact solution to the canonical problem.

The WF method has two advantageous features compared to more conventional ray-tracing techniques:

(a) The *number of rays is adjusted dynamically* in order to maintain an approximately constant resolution as the WF expands or shrinks, and

(b) the WF definition as a surface with connectivity properties enables us to achieve *accurate interpolation of fields associated with rays.*

We describe in more detail two elements of the method:

(1) an algorithm for generating edge-diffracted WFs, and

(2) a procedure for evaluating currents induced on the scatterer surface by incident, reflected, and diffracted WFs, which can be used in the context of integral equation based methods.

(1) In order to generate a diffracted WF, we first construct, by interpolation, rays emerging from a WF and hitting (within the given tolerance) those edges of the (triangulated) scatterer surface which may be considered a source of diffraction (i.e., edges whose adjacent faces are sufficiently non-coplanar). Next, from the edge points hit by the interpolating rays, we launch sets of diffracted rays (with the angular spacing appropriate for the required WF resolution). Finally, we create ray-ray connectivity data to define the triangulated surface of the new diffracted WF.

(2) We parameterize the currents induced on the scatterer surface in terms of "large-support basis functions" (LSBFs) defined on sets of triangles of the scatterer surface mesh of sizes dependent on the scatterer geometry, but independent of the frequency, and, typically, large compared to the wavelength. The LSBFs incorporate the notion that the asymptotic HF solution should be representable as a sum of products of rapidly oscillating exponential factors (due to specific HF scattering mechanisms), and smooth modulating functions.

We evaluate the surface currents by constructing intersections of "ray tubes" with the scatterer surface, and interpolating the field associated with the rays. (Ray tubes are defined here as prisms consisting of triplets of rays emerging from vertices of a triangle belonging to the WF mesh.)

The algorithm elements (1) and (2) allow us to obtain asymptotic solutions to HF scattering problems at a cost independent of the frequency, and dependent only on the complexity of the scatterer geometry.

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