Exact Solutions to Antenna Holography and Its Applications

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We present exact solutions to antenna holography problems based on near-field data over rectangular, spherical, or cylindrical enclosures. Full field distribution information in the source region is determined exactly, from two tangential field components over an enclosing rectangular, spherical, or cylindrical surface. All three components of both electric and magnetic fields in the antenna aperture are obtained exactly from two-component near-field data of either electric or magnetic type.

Conventional antenna holography relies upon back transformation for planar near-field data, and upon optimization schemes for both spherical and cylindrical near-field data. It is both acknowledged and accepted that the back transform is only an approximate solution due to its far-field nature, whereas optimization algorithms run the danger of convergence instability and, moreover, are computationally intensive. Our approach tackles holography by solving an inverse scattering problem, with exact solutions derived on the basis of three common types of near-field data. A mapping algorithm is proposed herein which determines the field everywhere, in both interior and exterior regions, based on a single-slice near-field data capture. It provides exact antenna holography solutions analytically, with the full electric and magnetic fields disclosed throughout the source region. The field mapping algorithm (**FMA**) is a direct, closed-form solution which is numerically straightforward and efficient. We couple our discussion of the **FMA** below by remarks concerning the existence and uniqueness of the holographic solutions thus obtained.

We have found that these exact solutions to holography are particularly useful in the arena of imaging techniques, such as medical imaging, land mine detection, through-the-wall imaging, and material properties measurement. Verification from a variety of perspectives is provided by analytic examples, numerical simulations, and outright hardware measurements. Ten test examples are presented. Analytic examples include dipoles, an azimuthal slot on a conducting sphere, and a uniformly energized circular aperture. A simulation example reveals the structure of a slotted array antenna based upon its near-field data as generated by a commercial software package. The hardware measurements likewise include a slotted array antenna, a patch antenna, and a base station antenna, along with materials of mixed, metallic/dielectric composition, as well as the imaging of biological tissue interiors. Excellent agreement is evident across all test cases.