Three Dimensional Source Reconstruction using Inverse Discrete Dipole Method

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Abstract

The inverse discrete dipole method (IDDM) source reconstruction technique is used to obtain harmonic current distribution on three dimensional objects from the known fields radiated by these objects. Examples of a reflector antenna, a Vivaldi patch antenna, and a horn antenna are presented. In some examples, the radiated field data is synthetic in that it is obtained from HFSS simulation of the antenna; in other cases the data is the measured field using a home made antenna range. The results clearly demonstrate the usefulness of the method.

1. Summary

Inverse source reconstruction is found in many fields, such as medical imaging and remote sensing [1]. In this paper, an inverse discrete dipole method (IDDM) based on an "Exact" discrete inverse source method proposed previously is developed [2, 3]. Its application to current visualization and localization from radiation-pattern measurements of an arbitrary three-dimensional radiator is presented. This method is "exact" in the sense that the only approximation involved is the discretization of the sources. Reconstruction of the harmonic current distribution is carried out from either the synthetic complex radiated field data or the measured field data. In a continuous source case, a discrete version of the source is recovered. Currents are visualized as an array of two dimensional Hertzian dipoles, where the magnitude and phase of each is found through the inversion process.

The IDDM method is developed after a brief introduction of the "Exact" discrete inverse source method for scalar sources. Inverse source problems [4] are generally ill-posed and as a rule a solution may not exist and it may be non-unique. In the present case, a discrete matrix operator **A**, relates the radiated fields and the sources. The rank deficiency of this matrix is often the cause of non-uniqueness. Ill-conditioning of the matrix is the cause of instability in the solution. Thus an iterative method, a variant of the conjugate gradient method is used to solve the system of equations.

The algorithm developed does not assume any a priori information about the source geometry and its current distribution. The equivalent source distribution is obtained from the simulated or measured complex electric field data sampled over a sphere for a radiating source in a homogeneous medium surrounding the source. Performance of this method in high signal to noise ratio is also demonstrated.

Examples include: a Vivaldi patch antenna on a dielectric substrate for which the electric data is generated with a commercial software package, HFSS; the horn antenna the radiated field data was obtained on a homemade antenna measurement range. Figure 1 shows the Vivaldi antenna geometry for HFSS simulation at 7 GHz. The dielectric substrate shown in yellow was not included in the simulation. The radiation field data was computed on a sphere of 30 ft. radius. Figure 2(a) shows the reconstructed currents in the plane of the antenna. Figure 2(b) shows the results for the point spread function (PSF) deconvolution from the reconstructed currents on the antenna. For convenience, in Figure 2 the outline of the antenna geometry is shown in red. The reconstructed source data clearly demonstrate the validity of the method.

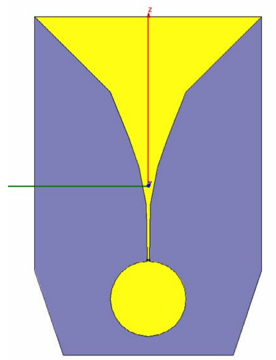
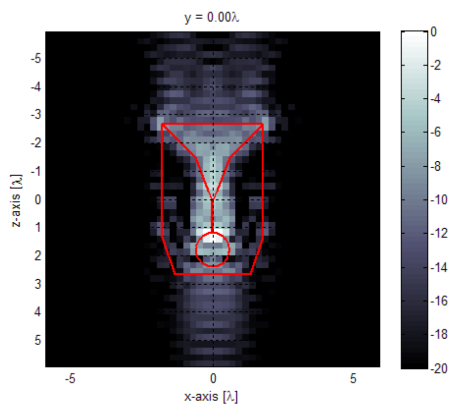
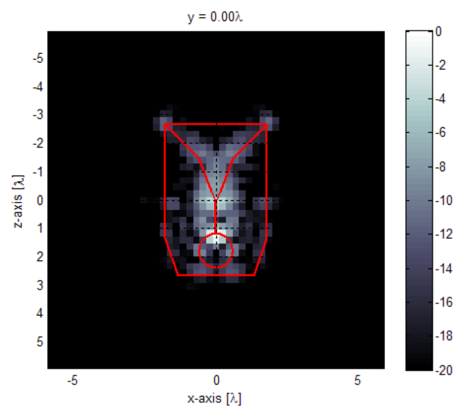


Figure 1. Vivaldi Antenna Geometry



(a)



(b)

Figure 2 (a) Reconstructed Currents (b) Reconstructed Currents after PSF Deconvolution

References

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