PIERS 1998

Progress In Electromagnetics Research Symposium

PROCEEDINGS

Volume 2

July 13-17, 1998
Nantes, France

Organised by
The Electromagnetics Academy
IRESTE, Université de Nantes
CESBIO, CNES-CNRS-Université Paul Sabatier, Toulouse
Institut Universitaire de Technologie, Université de Paris X

WEDNESDAY, JULY 15, AM

WEDNESDAY, JULY 15, PM

THURSDAY, JULY 16, AM

Microwave Backscattering Tomography by a Projected Landweber Method

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The problem addressed in this presentation is tomographic reconstruction of dielectric objects from coherent backscattering measurements. As is known, the main difficulty in solving this problem is the nonlinearity of the operator that relates the measurement data and the unknown function (the dielectric contrast of the object under test). The development of accurate nonlinear data models has led to quantitative reconstruction algorithms, that can be applied virtually for whatever contrast values, but are normally very expensive computationally. On the other hand, the spatial resolution achievable from linearized data models and linear algorithms is strongly limited by the need to tune the wavelength to physically justify the linear approximation. Another possible approach is to use a linear data model and a nonlinear algorithm, which also exploits generic prior knowledge on the solution, such as compact support, reality, and positivity. The projected Landweber method [1] is one of these nonlinear algorithms, and solves a constrained least squares problem on the residual between measured and computed data. If compared with the fully nonlinear approach, this strategy promises significant computational advantages, and the quality of the solutions is much higher than the one obtainable from linear reconstruction algorithms.

The first-order Born approximation enables us to derive a portion of the Fourier transform of the object function from measurement data. The algorithm is capable to extrapolate the known spectrum, thus achieving superresolution. In particular, for backscattering-only measurements the Fourier data available are band-pass in nature, and the extrapolation must be performed towards both the high-frequency and the low-frequency regions of the Fourier space [2]. The projected Landweber method can be related to the well-known Gerchberg spectrum extrapolation algorithm and to the iterative POCS approach to reach the intersection of some closed and convex subsets of a Hilbert space [3]. The convergence of the algorithm is sufficiently fast for practical purposes, and can be further accelerated by means of a suitable preconditioning.

I will recall some of the theory and report the results of some simulated experiments on dielectric objects probed by means of a very simple monostatic illumination-measurement system. I will also mention the possibility of applying the same procedure to lossy dielectrics and to limited-angle data.

References

[1] M. Piana, M. Bertero, "Projected Landweber Method and Preconditioning", *Inverse Problems*, Vol. 13, No. 2, pp. 441-463, 1997.

[2] E. Salerno, "Microwave Tomography for Compact-Support Dielectric Objects", *Int. J. of Imaging Systems and Technology*, Vol. 8, No. 6, 1997.

[3] E. Salerno, "POCS Approach for Imaging Dielectric Objects", *Proc. Progress In Electromagnetics Research Symposium*, PIERS'97, Cambridge, MA, 7-12 July 1997, p. 733.