

Quantitative microwave imaging of 3D inhomogeneous objects

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In this paper we present a microwave imaging algorithm for a three-dimensional (3D) inhomogeneous (lossy) dielectric object embedded in a homogeneous background medium. The object is illuminated with a given time-harmonic incident field and the scattered field is measured in a number of points surrounding the object. The goal of the algorithm is to reconstruct the complex permittivity distribution within the object.

In the forward problem the vector fields are computed by discretizing a contrast-source integral equation with a Method of Moments and solving the resulting linear system in an iterative manner with a bi-conjugate gradient approach. In the 3D case this is a computationally demanding task. Two approaches have been implemented to speed up the matrix-vector multiplications, either by applying Fast Fourier transforms either by using a Multilevel Fast Multipole Algorithm (MLFMA). The well-known stabilized biconjugate gradient FFT (BCGS-FFT) method (X.M. Xu *et al.*, *J. Appl. Comput. Electromag. Soc.*, 17(1), 97-103, 2002) requires a uniform cubic grid and $O(N \log N)$ operations; with the MLFMA the grid can be chosen in a more flexible way and the number of operations can be as low as $O(N)$.

The inverse problem is solved with a Newton-type non linear optimization technique applied to a least-squares cost function and involves the solution of the forward problem in each iteration step. Computational aspects are discussed and a combination of multiple incidences with multiple frequencies is investigated. Reconstructions from simulated data are presented for some 3D objects in the configuration of the bistatic microwave measurement setup of Institut Fresnel, France (J.M. Geffrin *et al.*, *Inverse Problems*, 21, S117-S130, 2005), where the transmitter and receiver can be moved on part of a spherical or a cylindrical surface surrounding the object.

