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Application of finite-difference time domain and dynamic differential evolution for inverse scattering of a two-dimensional perfectly conducting cylinder in slab medium

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Abstract. *We apply the dynamic differential evolution (DDE) algorithm to solve the inverse scattering problem for which a two-dimensional perfectly conducting cylinder with unknown cross section is buried in a dielectric slab medium. The finite-difference time domain method is used to solve the scattering electromagnetic wave of a perfectly conducting cylinder. The inverse problem is resolved by an optimization approach, and the global searching scheme DDE is then employed to search the parameter space. By properly processing the scattered field, some electromagnetic properties can be reconstructed. One is the location of the conducting cylinder, the others is the shape of the perfectly conducting cylinder. This method is tested by several numerical examples, and it is found that the performance of the DDE is robust for reconstructing the perfectly conducting cylinder. Numerical simulations show that even when the measured scattered fields are contaminated with Gaussian noise, the quality of the reconstructed results obtained by the DDE algorithm is very good.* © 2010 SPIE and IS&T. [DOI: 10.1117/1.3514737]

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1 Introduction

The detection and reconstruction of buried and inaccessible scatterers by inverting microwave electromagnetic measurements is a research field of considerable interest because of numerous applications in geophysical prospecting, civil engineering, and nondestructive testing. Numerical inverse scattering studies found in the literature are based on either frequency or time domain approaches. For frequency domain algorithms, the interaction of the entire medium with the incident field must be considered. In contrast, time-domain approaches can exploit causality to limit the region of inversion, potentially reducing the number of unknowns. Time domain inverse scattering problems thus appear quite often in the area of remote sensing. Most of the previously proposed inversion techniques for the inverse problems are formulated in the frequency domain.[1–8] However, the time domain scheme is a potential alternative for the inverse problems because the time domain data contain more information about scatterer than those in the scattered data of single frequency.

However, it is well known that one major difficulty of inverse scattering is its ill-posedness in nature.[9] Ill-posedness