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A New Approach for Solving Inverse Scattering Problems with Overset Grid Generation Method

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Abstract

This paper presents a new approach of Forward-Backward Time-Stepping (FBTS) utilizing Finite-Difference Time-Domain (FDTD) method with Overset Grid Generation (OGG) method to solve the inverse scattering problems for electromagnetic (EM) waves. The proposed FDTD method is combined with OGG method to reduce the geometrically complex problem to a simple set of grids. The grids can be modified easily without the need to regenerate the grid system, thus, it provide an efficient approach to integrate with the FBTS technique. Here, the characteristics of the EM waves are analyzed. For the research mentioned in this paper, the 'measured' signals are syntactic data generated by FDTD simulations. While the 'simulated' signals are the calculated data. The accuracy of the proposed approach is validated. Good agreements are obtained between simulation data and measured data. The proposed approach has the potential to provide useful quantitative information of the unknown object particularly for shape reconstruction, object detection and others.

Keywords: *finite-difference time-domain, forward-backward time-stepping, inverse scattering problems, overset grid generation method*

1. Introduction

Microwave inverse scattering technique is generally used to determine the location, shape and dielectric properties of unknown objects that are scattered by the objects [1]. The original geometrical features can be reconstructed from the scattered data received by the antennas and by numerically time reversing the scattering process. This technique is generally used for the reconstruction of early breast cancer due to its non-destructive effect on healthy tissue [2], military radar imaging [3], and tumour detection [4] and through the wall imaging [5-6]. In general, the inverse scattering techniques are developed in frequency-domain and time-domain for the microwave imaging [7-9]. The single frequency-domain scattering data is usually used in most of the microwave inverse scattering techniques to investigate the inverse problem [10-12]. However, frequency-domain scattering data is often ill-posed due to the nonlinearity and limited measurement parameters available enforced by the problem geometry [13]. In contrast, time-domain has the potential to reconstruct the dielectric properties more accurately [14]. It is therefore imperative to investigate different approaches to decrease the level of ill-conditioning inherent in the inverse problem.

The Forward Backward Time Stepping (FBTS) technique using broadband microwave signals is proposed to formulate the inverse scattering techniques in time-domain. This technique is an alternative approach to microwave imaging [15]. It is a nonlinear inverse scattering computation formulated in the time-domain utilizing Finite-Difference Time-Domain (FDTD) method. The FDTD method, original proposed by Kane Yee [16], proved to be a simple and efficient tool in solving Maxwell's equations. Generally, it is used to improve the detection and reconstruction of the objects [17-19]. The FDTD method contains more information compared to a single-frequency scattering data which would lead to improvements in detection rates. However, there are two major drawbacks to a classical FDTD method [20]. The first one is related to a situation when a two-scale problem occurs. This situation can be caused by a presence of object which is much smaller than the size of the problem. Here, the FDTD need to refine the computational domain globally to solve the problem. However, this method will

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