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Profile Reconstruction Utilizing Forward-Backward Time-Stepping with the Integration of Automated Edge-Preserving Regularization Technique for Object Detection Applications

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Abstract—A regularization is integrated with Forward-Backward Time-Stepping (FBTS) method which is formulated in time-domain utilizing Finite-Difference Time-Domain (FDTD) method to solve the nonlinear and ill-posed problem arisen in the microwave inverse scattering problem. FBTS method based on a Polak-Ribiète-Polyak conjugate gradient method is easily trapped in the local minima. Thus, we extend our work with the integration of edge-preserving regularization technique due to its ability to smooth and preserve the edges containing important information for reconstructing the dielectric profiles of the targeted object. In this paper, we propose a deterministic relaxation with Mean Square Error algorithm known as DrMSE in FBTS and integrate it with the automated edge-preserving regularization technique. Numerical simulations are carried out and prove that the reconstructed results are more accurate by calculating the edge-preserving parameter automatically.

1. INTRODUCTION

Inverse scattering in microwave imaging has been widely studied by many researchers for last decades. Microwave imaging [1] is a very promising approach for many practical applications. It has huge potential in measuring the characteristic of the embedded objects inside a bounded space region by illuminating electromagnetic waves. Microwave imaging has the ability to retrieve information about the distribution of the dielectric properties space region, the shape and the location of the embedded object. Besides that, microwave imaging has lower cost than other well-known screening approaches, for example, positron emission tomography and computed tomography. Furthermore, microwave imaging is safer with low nonionizing radiation than X-ray mammography. Thus, it is recommended that microwave imaging is applied as a diagnostic tool for several areas which involve civil and industrial engineering [2–5], nondestructive testing and evaluation [6–10], geophysical prospecting [11] buried object detection for military [12–14] medical diagnostic for biomedical engineering [15–19], and screening tool for wood industry [20].

Solving an inverse scattering problem is a very challenging task due to nonlinearity of the scattering equations, ill-posedness of the problem and uniqueness of the solution [21]. This problem could be dealt with either in frequency-domain or time-domain. The frequency-domain based technique has successfully reconstructed satisfactory results [22, 23], but it showed some drawbacks. Firstly, the use of higher frequencies may improve the spatial resolution, but it leads to highly nonlinear formulation and more complexity when measuring the scattered field. Secondly, collected information is limited

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