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B_2-Spline Interpolation Technique for Overset Grid Generation and Finite-Difference Time-Domain Method

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Abstract—In this paper, B_2-spline interpolation technique for Overset Grid Generation and Finite-Difference Time-Domain (OGG-FDTD) method was developed. B_2-spline or biquadratic spline interpolation offers better accuracy than bilinear interpolation. Two-dimensional (2D) numerical simulations were carried out for electromagnetic (EM) field analysis to measure the scattered fields for an unknown object in free space and dielectric medium. In this work, two antennas were utilised as transmitter and receiver sequentially to transmit microwave pulses and collect the scattered fields for an unknown object in OGG-FDTD lattice. In order to analyse the stability and efficiency of the proposed method, the scattered fields for the unknown object were investigated with error analysis. The results showed that the OGG-FDTD method with B_2-spline interpolation gave lower relative error than bilinear interpolation with 0.0009% of difference in free space, 0.0033% of difference in Case A dielectric medium, 0.236% of difference in Case B dielectric medium, and 0.003% of difference in Case C dielectric medium. Besides, the Mean Square Error (MSE) for the OGG-FDTD method with B_2-spline interpolation was also lower than the bilinear interpolation. Hence, it proves that the OGG-FDTD method with B_2-spline interpolation has the ability to measure the scattered fields around an unknown object accurately. For future work, the proposed method can be applied to inverse scattering to detect and reconstruct buried objects with arbitrary shapes in a complex media.

1. INTRODUCTION

Interpolation has attracted significant interest of researchers due to its potential utility and effectiveness in computer graphics, digital photography, multimedia, geology, agriculture and medical image processing applications [1–4]. Interpolation is the process of defining a function that matches the given data exactly. The function can be utilised to estimate the values that lie between known data points [5, 6]. It also seeks to fill in missing information in some small regions of the whole dataset. This technique can be used to produce a smooth graph of function for measuring or calculating. Besides that, the interpolation method is also useful in image processing for the enhancement of image zooming, reduction, resizing, decomposition, and sub-pixel image registration [7, 8].

There are several interpolation algorithms developed for image processing. Among the famous 2D interpolations are nearest neighbour interpolation [9], bicubic interpolation [10], bilinear interpolation [11], and B-spline interpolation [12–14]. The nearest neighbour interpolation is a simple and fast interpolation method, but the images produced are blurry [13]. On the other hand, bicubic interpolation provides sharper and better images, but it needs a large amount of calculation and takes more computational time [4, 15].

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