

High Order Adaptive Finite Difference Schemes for Maxwell's Equations

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Abstract

In this paper we discuss the use of the SPR (Sparse Point Representation) methodology for adaptive finite differences simulations in computational electromagnetics. The principle of the SPR method is to represent the solution only through those point values indicated by significant wavelet coefficients, which are used as local regularity indicators. Typically, few points are found in each time step, the grid being coarse in smooth regions, and refined close to irregularities. The method has two basic parts: a function representation and a discretization of the differential operator. In the representation part, there are wavelet tools containing decomposition and reconstruction operators defined by means of interpolating subdivision schemes. In the operational part, spatial derivatives are discretized by traditional uniform finite differences, using step sizes that can be made proportional to each point local scale. For the discretization of Maxwell equations, we investigate the effect on the accuracy and stability of the node arrangement for a class of high order finite difference schemes. In some cases, we consider staggered grids in the time-space domain for the magnetic and electric fields, as in the FDTD (Finite Differences Time-Domain) scheme. Moreover, we shall also consider cases where the grids coincide for both fields. A theoretical analysis shows that schemes in staggered grids may be preferable from the dispersion view point, specially for low order schemes and coarse grids. However, adapting the grid density and increasing the order, schemes for non-staggered grids also show good

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performance. Furthermore, the use of non-staggered grids increase the stability range and it has an easier implementation of adaptive strategies. In this direction, we show numerical simulations to demonstrate that the SPR method in non-staggered grids has a good potential for computational electromagnetics.