Analysis of Accuracy and Stability of A Novel FDTD Subgridding Algorithm by Introducing Nonuniform Grids to the Spatial Interfaces

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In a finite-difference time-domain (FDTD) calculation, subgridding algorithms are often employed to locally refine the mesh at regions containing fine structural features for problems involving multi-scale features. In existing algorithms, field calculations on the subgridding interface require special interpolation schemes which maybe result in late-time instability. Therefore, one of the major challenges of a subgridding algorithm is to develop the field coupling scheme to address the instability issue. In this work, we propose a novel FDTD subgridding algorithm with adaptively adjusted time-steps. Here, the concept of the nonuniform grid method is introduced to the field calculations on the subgridding interface. In the proposed FDTD framework, separate temporal and spatial interfaces are employed. An adaptively adjusted time-stepping procedure is used to achieve temporal synchronization for the magnetic fields at the temporal interface by a simple linear interpolation. Therefore, only spatial field interpolation needs to be carefully handled at the spatial subgridding interface. Similarly, the linear interpolation scheme also can be extended to obtain the magnetic fields at a 3D subgridding interface. A key contribution in this work is that the concept of the nonuniform grid method is introduced to properly handle the tangential electric component on the spatial interface of the two meshes. To test the accuracy and stability of the proposed method, a dielectric sphere with a radius of 7cm and a dielectric constant $\varepsilon_r = 9$ was considered. The proposed method was compared with the conventional FDTD method, where spatial increment is 1cm. In addition, the fine-cell FDTD method with spatial increment of 0.2cm was performed as a comparison basis. From the results as shown in Fig. 1, the proposed method is more efficient and faster than the fine-cell FDTD method while at the same time maintains the desired accuracy. For stability testing, the results show no sign of divergence after 300,000 time steps.

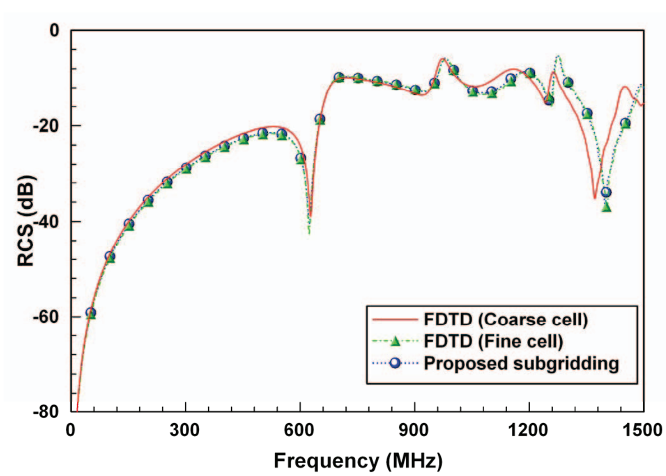

Fig. 1. Monostatic RCS as a function of frequency for a sphere of radius 7cm.