A Novel Iterative ADI Method with Field Splitting

Shumin Wang
National Institute of Health, 10 Center Dr. 10/B1D728, MD 20892,
U.S.A. Email: james.wang@ieee.org

The Alternating-Direction Implicit (ADI) method is a finite-difference time-domain (FDTD) method suitable for spatially over-sampled problems. Although the time-step size of the ADI method is no longer bounded by the Courant-Friedrichs-Lewy (CFL) condition, the traditional ADI method suffers large splitting error. Splitting error is a serious problem because it exists in simulations with relatively large field variations, such as the field associated with near-field sources, metal edges, corners and tips, etc.

To make the ADI method more practical, the iterative ADI method has been proposed to reduce the splitting error. This method interprets the traditional ADI method as a special relaxation solver of the Crank-Nicolson (CN) scheme. By applying a few iterations at each time step, the splitting error can be reduced effectively. Although conductive terms do not change the fundamental theory of the iterative ADI methods, their implementations make much differences in terms of efficiency. The appropriate treatment of conductive terms in TE case can be achieved by relatively simple matrix manipulations. However, it can not be carried on to lossy TM waves. To retain the efficiency of the ADI method and gain more accuracy, it is necessary to develop a scheme to properly handle conductive terms in TM waves.

Here, we present a novel approach by employing a split-field formulation. This scheme splits the electric field according to the two magnetic field components. As a result, a better system of equations are obtained that can be solved much more efficiently by the iterative ADI method. We note the difference between the splitting error and the split-field formulation. The splitting error is originated from splitting the CN operators, while both the electric and the magnetic fields are the original ones. In the split-field method, the electric field is split to construct a system suitable for the iterative ADI method.

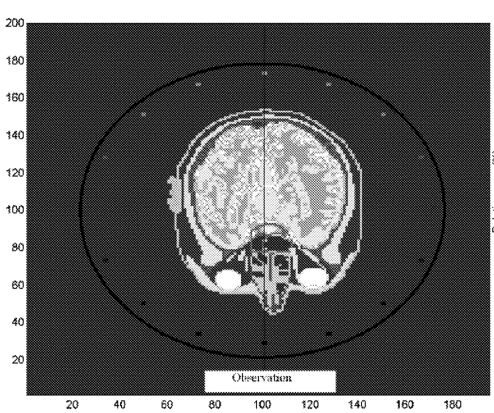

Figure 1: The 2-D head/coil system.

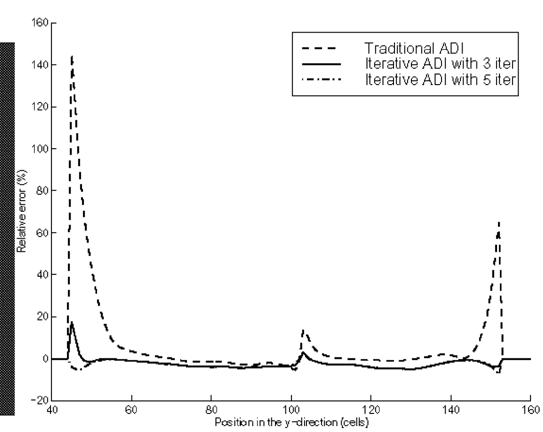

Figure 2: Relative error of E_z field in the head model along the central vertical line.