Abstract

Robust and Rapid scheme to solve electromagnetics (EM) is an important expectation in scientific computing environment, even though several useful methods and solutions are taking major roles to solve tasks in EM. Our research study is motivated with the thought of this deterministic need and targeted to develop a fast A-stable implicit numerical scheme and scalable software solution for EM wave propagation. Our scheme is developed based on the Method Of Lines Transpose (MOLT) approach which discretizes time first and solves boundary value problem. By applying the free space Green’s function, the solution is derived by decomposing particular and homogeneous solutions. The compact Simpson’s quadrature based, O(N) fast convolution, recursive algorithm is used to solve the particular solution for N number of grid points. The homogeneous solution is obtained using particular solution at the boundary points and boundary conditions applied. Multi-dimensional scheme is developed using ADI splitting approach and arbitrary order accuracy in time is achieved by switching the time derivation to spatial derivation using Lax-Wendroff approach.

The focus of the work on this thesis has been to overcome the limitations in Neumann and outflow boundary condition to get high-order accuracy by using special treatments that deal with a choice of the interpolation, finite difference stencil, and initial condition. In addition, we have extended these ideas to construct perfectly electrically conducting boundary condition in 2D for the MOLT.

In addition to introducing higher order boundary condition, an embedded boundary method is employed to deal with complex geometries. As the method is A-stable, it does not suffer from small time step limitations that are found in explicit finite difference time domain methods when using either embedded boundary or cut cell methods to capture geometry. Further, we are developing an open source code MOLTN (Method Of Lines Transpose, Nth order) which is intended to be a hardware-independent, scalable software tool, using multi-node MPI, multi-core OpenMP, and GPU CUDA implementation. As a test case of the method, we implement and study the A6 magnetron with our embedded boundary method using point
sources inside of the domain.

The eventual goal is to combine this method with a novel particle method for the simulations of plasma. The particle method would treat particles as point particles that generate fields that are tracked on the mesh. No density or current will be mapped to the mesh. So far, the consistency and performance of the scheme are evaluated for EM wave propagation and scattering using different shaped objects including curved boundaries, including the introduction of true point sources that demonstrate how we will look to handle particles. Stable solutions result for a wide range of mesh sizes and potential to leverage novel computing architectures, such as GPU, have been demonstrated.

Publications


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