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ABSTRACT

Parallel computing methods and mathematics libraries were surveyed and practiced for parallel FETD implementations. New FETD formulations were theoretically developed and compared with the existing FETD formulation.

RESEARCH GOALS

The specific research goals of this quarter were to

- Determine a proper parallel programming model and parallel computing libraries for parallel FETD implementations.
- Develop and evaluate different FETD formulations in order to choose the best FETD formulation in a parallel computing environment.

ACCOMPLISHMENTS

Through literature reviews and discussions, Intel Math Kernel Library (MKL) was chosen for my work. This library is based on OpenMP Application Programming Interface and includes both Pardiso direct solver and Intel iterative solver. Sample codes written in MKL and OMP practice codes were successfully tested in CEES machines.

The current serial FETD formulation is based on the electric field Helmholtz equation. In order to examine if or not the current FETD formulation is the best choice for parallel implementations, I developed additional two FETD formulations. They are based on the coupled Maxwell's equations and magnetic vector potential equation, respectively. In short, the current serial FETD formulation would be the best choice with a direct solver in the parallel computing environment. In contrast, magnetic vector potential FETD formulation would be the best choice with an iterative solver in the parallel computing environment. The FETD formulation with the coupled Maxwell's equations seems to be the worst choice for my problem and will not be considered any more. The detailed formulation procedures and their features are discussed in the separate *appendix* document (I already emailed it to you).

In conclusion, the current serial FETD formulation with the electric field Helmholtz equation will be primarily used in a planned parallel version because a direct solver shows an extremely robust performance. However, the possibilities of the magnetic vector potential FETD formulation are still being tested so that large memory requirements associated with a direct solver can be mitigated.

SUMMER RESEARCH PLANS

From this summer, my research topics will be gradually moved from computational electromagnetic geophysics to classic electromagnetic geophysics.

- Real data acquisition from EMI or Shell:
    - Understand basic work flow for real data processing.
    - Run simulations of real field data.
    - Understand limitations of both modeling and real data.
    - This work schedule is not clear yet but depends on data availability.

- Anisotropy, topography and multi-source CSEM arrays for reservoir monitoring:
    - The topics will be connected with real data available to me.
    - The first step for the research topics is to make it possible to visualize transient current diffusion phenomena in complex environments. Since the visualization requires a number of numerical detectors in a model, a resultant problem size would be very large. This problem will be addressed below.

- Efficient FETD formulations for large problems in parallel computers:
    - The numerical aspects of the magnetic vector potential FETD formulation are being examined. If it can be solved in numerically stable ways, it can also serve as a new algorithm for FEFD simulations.
    - Provide complete understanding of EM geophysical FETD formulations.
    - Convert the current FETD algorithm into its corresponding FD algorithm.
    - Parallel FE implementations with minimal programming costs.