Faster Micromagnetic Simulations with Graphics Processing Units

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We have demonstrated high-performance finite element micromagnetics simulator utilized by the massively parallel processing architecture of GPU(graphics processing units). Using μMAG standard example problems, the calculation performance of GPU-based parallel micromagnetic simulator is improved to 10-100X compared to CPU-based singled-threaded micromagnetic simulator. The speed-up ratio depends on problem details, cell size, calculation precisions, but the improvement is more remarkable as the number of cells increasing. We uses Intel Core i7 CPU and NVidia Geforce GTX 480 GPUs for comparison.

The GPU-based micromangetic simulator uses parallelled fast multipole method(FMM) to evaluating the magnetic scala potential $\phi(\boldsymbol{r})$ given by

$$\phi(\boldsymbol{r}) = \frac{1}{4\pi}\Sigma_i \frac{\rho(\boldsymbol{r})}{|\boldsymbol{r}-\boldsymbol{r_i}|}\Delta V$$

at each lattice. And Landau-Lifshitz equation is solved by fourth-order Runge Kutta method with adaptive time stepping which is employed to well-known micromagnetic simulator such as OOMMF. The simulation results is in good agreement with ones given by OOMMF.

We expect that micromagnetic simulation on real-device scale magnetic system such sub-nanometer dot array system, 3D-structured micromagnetic system is avaliable by utilizing the high performance of GPU-based micromagnetic simulator.