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Optimization of a Multi-Dimensional FFT Library for Accelerating Magnetostatic Field Calculations

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Calculation of Magnetostatic fields is well known to be a main source of computational bottleneck in micromagnetic simulations [1]. Consequently, recent developments in the simulator landscape involve the usage of throughput oriented hardware architectures. Since these hardware units provide support for massive parallelism, they are well suited for running industrial scale simulations. Efforts to parallelize these computations are predominantly focused on shared memory architectures and graphic cards [1,2]. The computation of the magnetostatic field involves a convolution operation between the self magnetization and a shape dependent demagnetizing tensor. For performance reasons, most solvers take advantage of the convolution theorem, using which the operation is reduced to a point wise multiplication in Fourier space. As a consequence, micromagnetic solvers are dependent on the availability of fast FFT Libraries such as cuFFT by NVIDIA. Naturally, it's usage limits the solvers to NVIDIA based graphic cards only. Since the library code is proprietary, it is also difficult to modify it for exploiting some known symmetric properties of the convolution product. In this paper, we introduce a version of our OpenCL based FFT library specifically optimized for magnetostatic field computations. The OpenCL specification allows solvers to run not just on cross-vendor GPU's, but also on additional types of hardware such as CPU's and FPGA's. Our library provides support for 1D and higher dimensional transforms for near arbitrary length inputs. Furthermore, our library supports distributing the FFT's across multiple GPU's. Our initial benchmark and profiling results report our library to be 48 times faster than a single CPU based FFTW code and 3 times faster than NVIDIA's cuFFT library. The results are averaged for various input sizes involving complex-to-complex transforms.
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