

Implementation of the lattice Boltzmann method on the graphics processing unit

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The lattice Boltzmann method (LBM) is a numerical method derived from the Boltzmann equation and kinetic theory. Contrary to the conventional computational fluid dynamics methods that discretize and solve the Navier-Stokes equations, the LBM uses discrete particle velocity distribution functions based on microscopic fluid physics to simulate the hydrodynamic flow field. Apart from its proven accuracy and ease of implementation, one of the main advantages of this method is the data locality in the algorithm, which makes it ideal for implementing on parallel architectures, such as the Graphics Processing Unit (GPU). Although GPUs have many restrictions in its operation and programming, recently, there has been an increased interest in using them for general purpose calculations, for its high processing power that it harnesses from its massively multi-core architecture. In this study, the LBM is realized on the GPU using nVidia's Compute Unified Device Architecture (CUDA), a programming architecture developed specifically to utilize the processing power of GPUs. One of the main challenges in achieving high performances on the GPU is the memory access patterns, which is particularly important for memory bound algorithms such as the LBM. In this seminar, a novel GPU implementation of the LBM with grid refinement capabilities is presented. It is shown that the GPU code can achieve speed ups of up to two orders of magnitude compared to a typical CPU implementation, and that the performance overhead from managing locally refined grids is negligible.