A LATTICE BOLTZMANN 3D-GPU-IMPLEMENTATION ON NON-UNIFORM GRIDS

Martin Schönherr, Martin Geier, Maik Stiebler and Manfred Krafczyk

TU Braunschweig
Institute for Computational Modeling in Civil Engineering (iRMB)
38106 Braunschweig, Germany,
e-mail: {schoenherr,geier,stiebler,kraft}@irmb.tu-bs.de

ABSTRACT

Since the NVIDIA Compute Unified Device Architecture (CUDA) SDK has been released, multiple publications have demonstrated that simulations in the field of Computational Fluid Dynamics (CFD) may substantially benefit from the utilization of General Purpose Graphics Processing Units (GPGPU), which offer a high performance vs. price ratio compared to classical CPUs typically used in PC clusters.

The lattice Boltzmann equation for fluid dynamics is derived from the continuous Boltzmann equation, which describes the probability of finding a fluid particle in a certain velocity state at a certain position and at a certain time. The classical Lattice Boltzmann Method (LBM) is structurally restricted to run on uniform Cartesian grids with a single global time step only. It is obviously desirable to change the resolution of the method from fine grids and short time steps in regions of high interest to coarse grids and long time steps in regions of low interest, typically the peripheral regions of the flow field. Grid refinement approaches mainly have been developed for CPU implementations and do not automatically lead to good performance on GPGPUs. A local grid refinement with low data transfer, a compact memory access pattern and little exceptions at the edges and vertices of the interface is desirable.

We present a three dimensional multi scale lattice Boltzmann implementation based on a uniform GPGPU code [1]. For the grid refinement, we use the method of [2] which basically preserves the locality of the LBM and does not lead to a performance degradation on GPGPUs. Our study will thus also address the performance of the multi scale implementation in relation to the uniform grid code.

REFERENCES

[1] J. Tölke and M. Krafczyk, TeraFLOP computing on a desktop PC with GPUs for 3D CFD, *International Journal of Computational Fluid Dynamics 22:7*, pp. 443 - 456 (2008)

[2] M. Geier, A. Greiner, and J.G. Korvink, Bubble functions for the lattice Boltzmann method and their application to grid refinement, *The European Physical Journal Special Topics 171*, pp. 173 - 179 (2009)