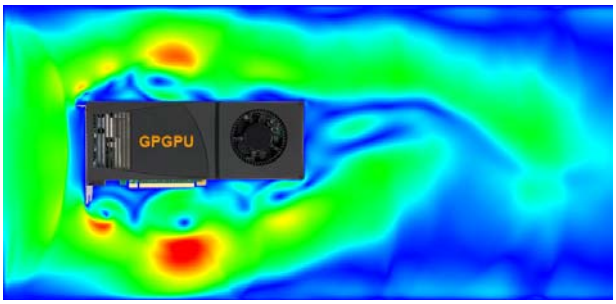
Numerical simulation of fluid flow on GPGPUs using the Lattice Boltzmann Method

About one decade ago, researchers started to use programmable vertex and pixel shader units of graphic processors (graphics processing units, GPUs) to run scientific code on common graphic cards [1]. Although the speedup was promising, programming itself was very involved due to the specialization of the instruction set for rendering purposes. In 2007 nVidia released a general purpose programming language called CUDA C for their GPU platform CUDA, shortly afterwards Apple released an open standard called OpenCL. GPUs then turned into so-called general-purpose GPUs, in short GPGPUs.



This development had a huge impact on the numerical simulation of fluid flow with the lattice Boltzmann method (LBM) [2]. LBM emerged from statistical physics and was proven to be a valuable tool for the simulation of the dynamics of fluids [3]. Although the derivation of the method is mathematically involved, its implementation is simple and very efficient. LBM is especially well suited for high-performance implementations on GPGPUs.

The idea of this software lab project is to implement a lattice Boltzmann kernel on a GPGPU. We will guide you along the way as you develop your own lattice Boltzmann GPGPU code.

Within this software lab you will:

1. Study the lattice Boltzmann method by reviewing literature and a 2D Matlab tutorial code
2. Develop your own C++ 2D LBM code
3. Familiarize yourself with the CUDA hardware platform and the CUDA C programming language
4. Implement a 2D LBM kernel for nVidia GPGPUs

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References

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[2] Tölke: “Implementation of a Lattice Boltzmann kernel using the Compute Unified Device Architecture developed by nVidia”, Computing and Visualization in Science, Volume 13, Number 1, 29-39, 2008
[3] http://www.lbmethod.org