Sailfish: GPU-based fluid simulations with the lattice Boltzmann method

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The Sailfish framework

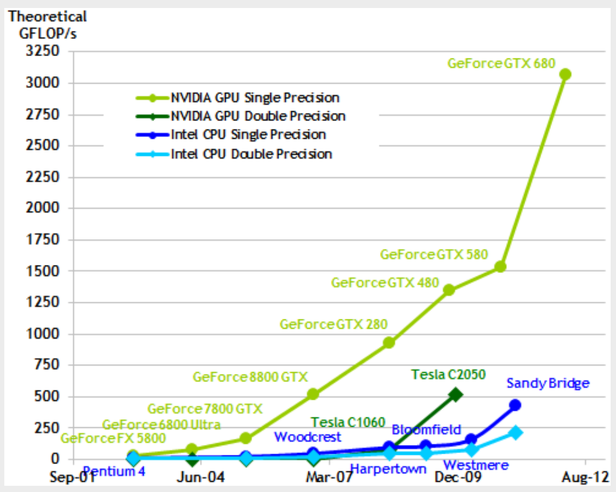
Sailfish is an open source (LGPL) project which has been under development since 2009. It employs template-based **run-time code generation** and **computer algebra** techniques to automatically generate optimized code for the GPU. Sailfish is written primarily in **Python.**

mako python SymPy

Current capabilities

- single phase and binary fluid flows
- simulations in single and double precision
- turbulence models (entropic LB, Smagorinsky LES)
- **distributed simulations** on LSF and PBS clusters
- support for various LB models and boundary conditions
- best in class performance
- simple on-line visualization
- support for **OpenCL** and **CUDA** devices
- runs on Linux, Mac OS X, and Windows

Why GPUs?

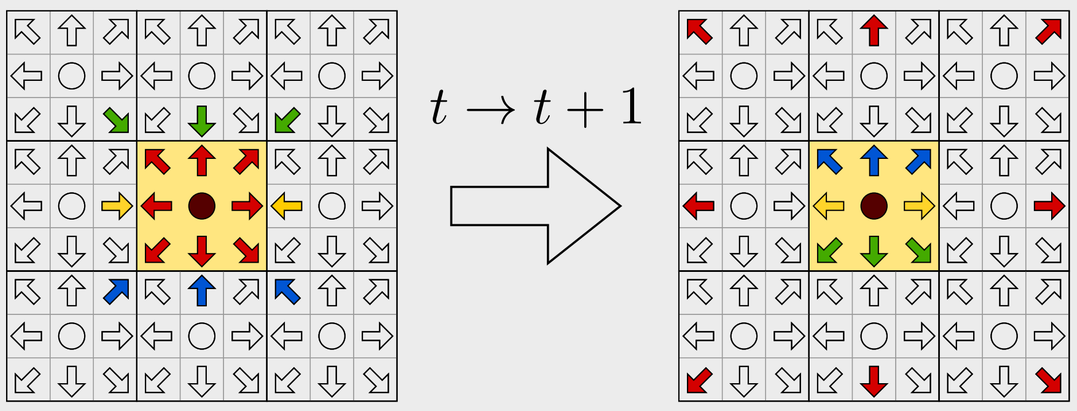


- several TFLOPS computational power in a single device
- cheaper than equivalent CPU setup (especially gaming GPUs!)
- fast main memory (~200 GB/s)
- easy to program via CUDA or OpenCL

Sample simulations

The Lattice Boltzmann method

The LBM is an **alternative to direct solution** of Navier-Stokes equations. The fluid is described at the **mesoscopic level** by a set of mass fractions $f_i(\Rightarrow)$, which are associated with nodes of a **Cartesian lattice.**



Basic algorithm (LBGK model):

$$f_i(\vec{x}+\vec{c}_i, t+1) = f_i(\vec{x}, t) - \frac{f_i(\vec{x},t) - f_i^{eq}(\rho_i, \vec{v}_i)}{\tau}$$

Local / nearest-neighbor interactions are **great for parallel calculations.**

Contributions wanted!

Sample projects:

- automated domain partitioning
- grid refinement
- fluid-structure interaction
- simulation set-up UI
- better online visualization
- new LB models
- new LB boundary conditions
- automated perfomance tuning

You **don't need to be a physicist** or fluid dynamics engineer to be able to help!