The 18th International Conference on Finite Elements in Flow Problems (FEF2015)
16-18 March 2015, Taipei, Taiwan

A Research on Particle-Based Parallel Methods for Fluid Animation

Feng-Quan Zhang [1] and Liu-Qing Xu [2]

[1]Department of College of Computer Science,
North China University of Technology, Beijing, 100144, China
fqzhang@ncut.edu.cn
[2] Institute of Remote Sensing and Digital Earth Chinese Academy of Sciences,
Airborne Remote Sensing Center, Beijing, 100094,China
lqxu@ceode.ac.cn

Key Words: *Fluid Simulations, SPH Methods, Parallel Computing.*

Although finite elements can create attractive fluid animation, they cannot produce the realistic appearance and behavior when it is used for problems involving large deformations and material fracture. Smoothed Particle Hydrodynamics (SPH) has strong ability in modeling large deformations application. However, a high computational burden makes it impossible for it to meet the requirement of generating and rendering realistic fluid using interactive frame rates.

To this end, we present an acceleration strategy for SPH on multi-GPU platform. For single-GPU, we first use a neighbour search algorithm of cell index combined with spatial domain characteristics. Subsequently, two optimizations are made. To solve code divergence problem we merge continuous cells into a huge cell to reduce synchronization point in traditional implementation. By decreasing the cell size, less potential particles are searched in neighbour search. For multi-GPU, we focus on the changing patterns of SPH's computational time. Simple dynamic load balancing algorithm works well because the computational time of each time step changes slowly compared to previous time step. By further optimizing dynamic load balancing algorithm and the communication strategy among GPUs, a nearly linear speedup is achieved in different scenarios with a scale of millions particles. The quality and efficiency of our methods are demonstrated using multiple scenes with different particle numbers.

We have enforced and tested all methods using our platform as follows: Windows7 OS, 2x 32-Bit Intel Xeon EightCore E5620 @2.40GHZ, 6GB RAM and 4x GeForce GTX 480 with 1.5GB VRAM.

Figure 1 shows the final speedup of multi-GPU SPH implementation via communication optimization using optimized dynamic load balancing algorithm. The performance of multi-GPU increases by about 10%. Multi-GPU's speedups all exhibit the trend of linear acceleration when different numbers of GPUs simulate millions scale scenario.

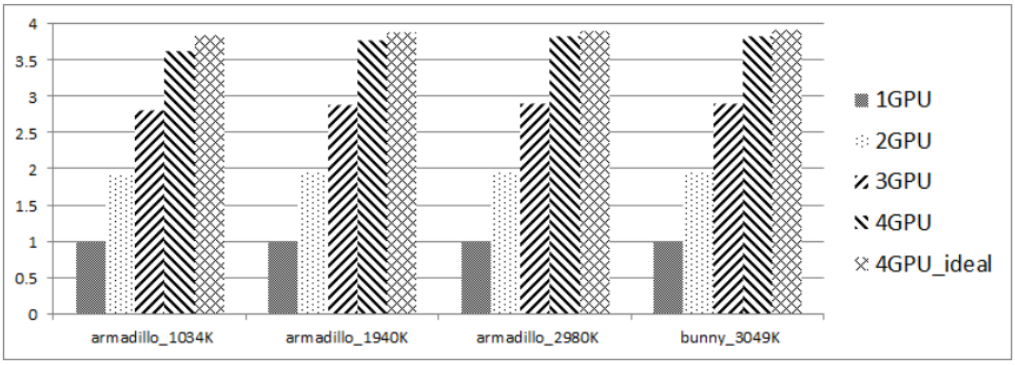

Figure 1: Speed up

Figure 2 shows an animation of ”bunny”. The scene is implemented on the four GPUs and the four different colors denote four GPUs. In each iteration step, the GPUs load is adjusted dynamically with our presented method for balance.

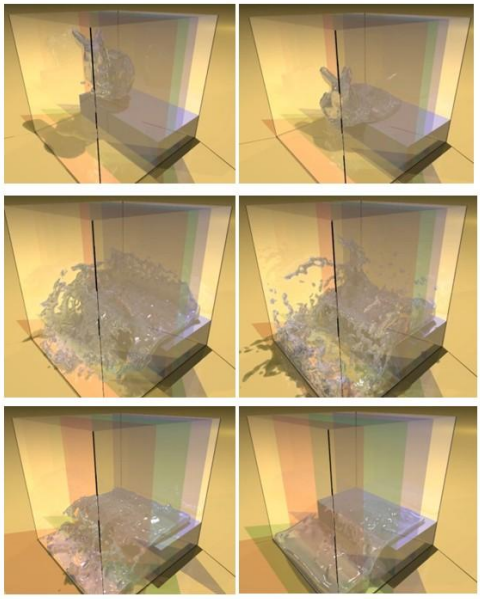

Figure 2: Fluid animation

REFERENCES

[1] Monaghan, J. Gingold, R. Smoothed Particle Hydrodynamics. Annu.Rev.Astron Astrophys 1992; 30, 543-574.

[2] Monaghan J. Simulating Free Surface Flows with SPH. Journal of Computational Physics 1994; 110(2), 399-406.

[3] Green S. Particle-based Fluid Simulation. http://developer:download:nvidia:com/presentations/2008/GDC/GDC 08 Particle Fluids.pdf, 2008.

[4] Müller, M., David, C., Markus, G. Particle-based Fluid Simulation for Interactive Applications. In Symposium on Computer Animation 2003; 154-159.

[5] Rustico. E and Bilotta. G et al: A journey from single-GPU to optimized multiGPU SPH with CUDA. 7th SPHERIC Workshop, 2012.

[6] J. M. Dominguez and A. J. C. Crespo et al: New multi-GPU implementation for smoothed particle hydrodynamics on heterogeneous clusters. Computer Physics Communications, 2013.

Acknowledgements: This research work is supported by fund of PXM2014_014212_000097 and Y3SJ6600CX.