Large-scale Particle-based Simulations for Granular and Fluid Dynamics using Dynamic Load Balance on a GPU supercomputer

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ABSTRACT

We carry out simulations based particle method such as DEM (Discrete Element Method), SPH, and fluid-structure interaction with DEM-SPH coupling on GPU supercomputer TSUBAME2.5 at GSIC, Tokyo Tech. For large-scale computations, domain decompositions are reasonable ways to achieve a high performance for parallel computing on supercomputers with multiple nodes. However, when we use static domain decomposition, the particle distribution changes in time and the computational load for each domain becomes quite non-equal.

In this study, we introduce an effective method to realize the dynamic load balance of particle simulations. Applying the slice-grid method to the domain decomposition, we maintain the same number of particles in each domain. Several sophisticated techniques for particle counting and data movement have been implemented. The time integration causes memory fragmentation for particle variables and the frequency of the memory de-fragmentation is examined by taking account for the cost of the data communication between CPU and GPU. A link-list technique of the particle interaction is introduced to save the memory drastically.

We demonstrate several DEM simulations: a golf bunker shot using 16.7 million particles with 64 GPUs in Fig.1, a conveyer with screw, an agitation analysis, a spiral slider and so on. The strong and weak scalabilities for the benchmark test from 0.1 to 1.0 billon particles on TSUBAME2.5 equipped with 4224 NVIDIA Tesla K20X were measured. It is shown that our simulation code works well with a good scalability.

Several fluid and fluid-structure simulations using SPH, DEM-SPH are executed for free surface problems. Figure 2 shows the simulation result of the dam break problem interacting with the statue of liberty using 72 Million particles with 80 GPUs.

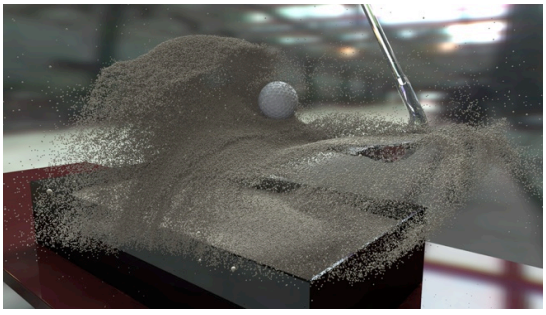

Fig. 1 A golf bunker shot.

Fig. 2 A dam break simulation.

REFERENCES

[1] S. Tsuzuki, T. Aoki: Large-scale granular simulations using Dynamic load balance on a GPU supercomputer, SC14 Regular, Electronic, and Educational Poster, International Conference for High Performance Computing, Networking, Storage and Analysis 2014 (SC14)