Large-scale Simulations for Fluid-particle Systems Using Coupled LBM-DEM on a GPU Supercomputer

Seiya Watanabe*, Takayuki Aoki† and Yuta Hasegawa††

* School of Engineering at Tokyo Institute of Technology
2-12-1-i7-3 Ookayama, Meguro-ku, Tokyo
e-mail: watanabe@sim.gsic.titech.ac.jp

† Global Scientific Information and Computing Center at Tokyo Institute of Technology
2-12-1-i7-3 Ookayama, Meguro-ku, Tokyo
e-mail: taoki@gsic.titech.ac.jp

†† School of Engineering at Tokyo Institute of Technology
2-12-1-i7-3 Ookayama, Meguro-ku, Tokyo
e-mail: hasegawa@sim.gsic.titech.ac.jp

ABSTRACT

A code of direct numerical simulations has been developed for large-scale fluid-particle systems. In order to accelerate the simulations, graphics processing unit (GPU) is used in our implementations. The lattice Boltzmann method (LBM) suitable for GPU computing and large-scale simulations is used for to compute fluid dynamics. In order to improve the accuracy and the stability, the D3Q27 multiple-relaxation-time (MRT) collision operator[1] and a large eddy simulation model have been employed . We apply DEM (Discrete Element Method) to compute particle motions. Several large-scale simulations are performed by using multiple GPUs on a supercomputer.

We demonstrate a large-scale spouted bed simulation with 81,920 solid spherical particles and 512×512×1536 lattice nodes on 48 GPUs. Figure 1 shows the snapshots of the spouted bed simulation. The left panel shows the particles colored by their initial positions and the right one is the fluid velocity profile in the z-direction. As an example of gas-solid flows containing complex shape objects, we have conducted a simulation for falling ginkgo leaves with 1024×1024×2048 nodes shown in Fig.2.

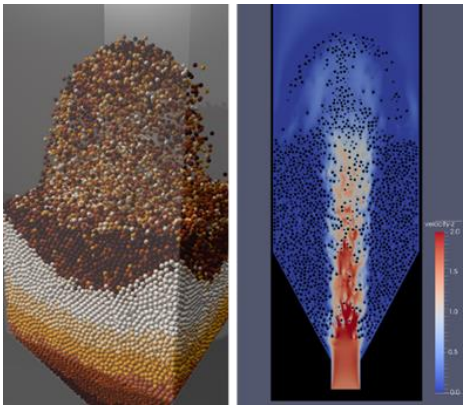

Fig. 1: A result of a spouted bed simulation with 81,920 solid particles.

Fig. 2: A result of a falling ginkgo leaves simulation with 1024×1024×2048 nodes using 128 GPUs.

REFERENCES

[1] Suga, K., Kuwata, Y., Takashima, K., & Chikasue, R. A D3Q27 multiple-relaxation-time lattice Boltzmann method for turbulent flows. Computers & Mathematics with Applications, 69(6), 518-529 (2015).