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A LARGE-SCALE PARTICLE SIMULATIONS USING DYNAMIC LOAD BALANCE ON GPU SUPERCOMPUTER

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Distinct Element Method (DEM) is used for numerical simulations of granular mechanics. Particles move due to contact interactions with near particles in both the normal and the tangential directions. Granular phenomena often consist of more than billions of particles. Due to computational resources, a single particle has to represent more than 10 thousands particles in the previous simulations. In order to bring these simulation closer to the real phenomena for the purpose of quantitative studies, it is necessary to carry out large-scale DEM simulations on modern high-performance supercomputers.

We have developed a DEM simulation code for supercomputers equipped with GPUs. Domain decomposition is a reasonable way for the DEM algorithm and suitable for computations on multiple nodes. However, the spatial particle distribution changes in time and the computational load for each domain becomes quit non-equal in the static domain decomposition.

In this study, we apply the slice-grid method to dynamic load balance for large-scale DEM simulations and it is found that each domain has the same number of particles during the whole simulation time[1]. Figure 1 illustrates the two-dimensional slice grid method to devide the computational domain to keep the same number of particles..

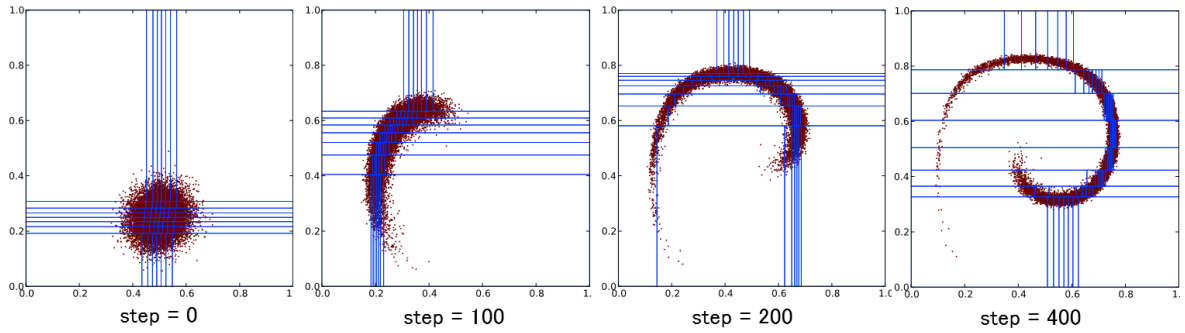

Fig1. Dynamic load balance

Several techniques of GPU memory management have been developed to move the particle data across the domain boundaries. The increase of the time step causes memory fragmentation and the frequency of the memory de-fragmentation is optimized for the cost of

the data communication between CPU and GPU. In addition, a linked-list technique for the table of particle interactions is introduced to save the memory drastically.

We demonstrate several DEM simulations as shown in from Fig.2 to Fig5, a golf bunker shot using 130 million particles with 256 GPUs, a conveyer with screw, an agitation analysis, a spiral slider and so on, which were carried out on TSUBAME supercomputer in Tokyo Institute of Technology.

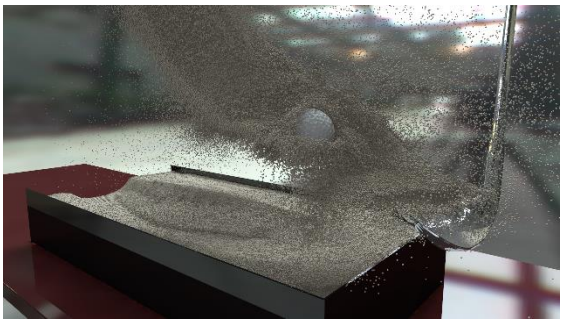

Fig2. Golf bunker shot

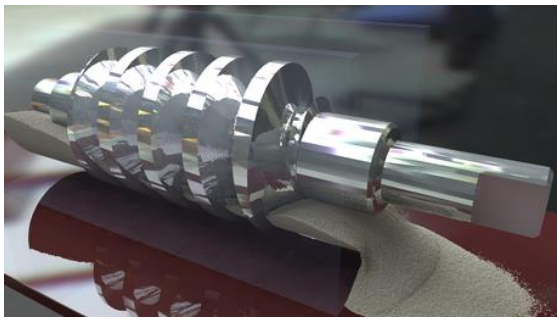

Fig3. Conveyer with screw

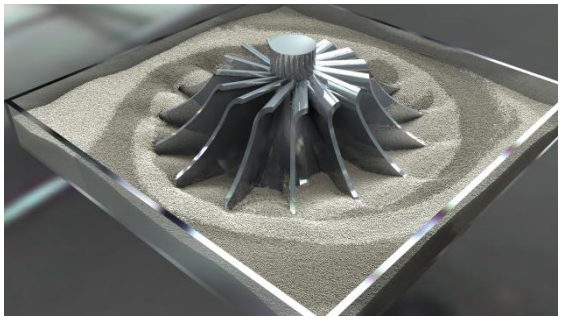

Fig4. Agitation analysis

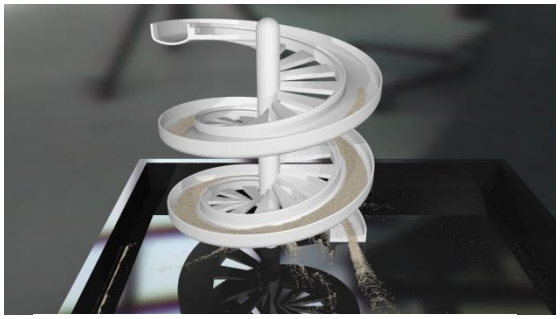

Fig5. Spiral slider

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