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Validation of the GPU based BLAZE-DEM framework for hopper discharge

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Abstract

Understanding the dynamical behavior of particulate materials is extremely important to many industrial processes, with typical applications that range from hopper flows in agriculture to tumbling mills in the mining industry. The discrete element method (DEM) has become the defacto standard to simulate particulate materials. The DEM is a computationally intensive numerical approach that is limited to a moderate amount (thousands) of particles when considering fully coupled densely packed systems modeled by realistic particle shape and history dependent constitutive relationships. A large number (millions) of particles can be simulated when the coupling between particles is relaxed to still accurately simulated lesser dense systems. Massively large scale simulations (tens of millions) are possible when particle shapes are simplified, however this may lead to oversimplification when an accurate representation of the particle shape is essential to capture the macroscopic transport of particulates. Polyhedra represent the geometry of most convex particulate materials well and when combined with appropriate contact models predicts realistic mechanical behaviour to that of the actual system. Detecting collisions between polyhedra is computationally expensive often limiting simulations to only hundreds of thousands of particles. However, the computational architecture e.g. CPU and GPU plays a significant role on the performance that can be realized. The parallel nature of the GPU allows for a large number of sim- ple independent processes to be executed in parallel. This results in a significant speed up over conventional implementations utilizing the Central Processing Unit (CPU) architecture, when algorithms are well aligned and optimized for the threading model of the GPU. We recently introduced the BLAZE-DEM framework for the GPU architecture that can model millions of spherical and polyhedral particles in a realistic time frame using a single GPU. In this paper the authors validate BLAZE-DEM for hopper discharge simulations. The authors firstly compare the flow-rates and patterns of polyhedra and spheres obtained with experiment to that of DEM. They then compare flow-rates between spheres and polyhedra to gauge the effect of particle shape. Finally, they perform a large scale DEM simulation using 16 million

particles to illustrate the capability of BLAZE-DEM to predict bulk flow in realistic hoppers.