Large-scale Debris-blastwave Interaction Simulation using GPU supercomputer

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ABSTRACT

A large-scale simulation for debris-blastwave interaction has been carried out. The model is a grid-based compressible fluid computation coupling with Distinct Element Method (DEM). An object is represented as a group of small sphere particles rigidly connected each other. Collisions between objects are evaluated by using DEM interactions. The fluid dynamics computation is governing by Navier-Stokes equations by solving with 3rd order MUSCL scheme. The Level set method is used to represent object shapes for the computational domain for fluid. Due to the conservation lost problem when we apply the existing immersed boundary method to strong compressibility flows, an improved method for high compressible flow is proposed. Hereby we present a debris-blastwave interaction simulation. A high explosive is set in the center of a cube structure surrounded by four unbreakable walls and one wall which is constructed with 81 already broken debris (blocks), neighbouring by another wall structure represented with 49 blocks and a unbreakable boundary. Simulation domain is set to $5m \times 5m \times 4m$ area with $800 \times 800 \times 640$ grid points. Our simulation code has been implemented for multiple GPUs to achieve high performance. Debris accelerated and reflected by the blastwave, as well as collisions interaction between debris hitting were successfully reproduced. It is found that the debris was accelerated by the explosion and reached a maximum speed of 301.1 m/s at 2.26 ms. Where 2.40 % ($= 2.31 \times 10^5$J) of the energy of the high explosive were transferred to the debris kinetic energy (excludes the unbreakable walls and boundary).

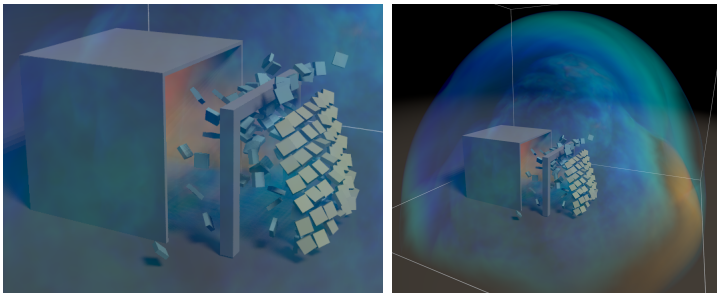

Figure 1: Large-scale simulation of massive debris driven by the blastwave.

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