Comparing open-source DEM frameworks for simulations of common bulk processes

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ABSTRACT

Various discrete element method (DEM) based softwares exist for modelling granular materials. All of them employ the same principles of explicit time integration, where three main steps, namely contact detection, the calculation of interactions and the integration of motion are iteratively executed. Despite these similarities, there exist significant methodological differences, such as the numerous domain decomposition techniques used for efficient contact detection, the various particle-wall contact models, and the different shear force collection and application methods. Moreover, significant differences can be observed in the practical implementation of these systems including data management structures, parallelization techniques, user interaction, and documented resources.

Choosing the right software to simulate a particular process can be challenging. This work aims to address this issue by comparing and benchmarking nine widely-used simulation frameworks: Blaze-DEMGPU, ESyS-Particle, GranOO, Kratos Multiphysics, LIGGGHTS, MercuryDPM, MFiX, MUSEN and YADE. Only open-source software packages were considered, since these are freely available and their underlying algorithms can be reviewed and tested. The benchmark consists of three common bulk processes: emptying of a silo, mixing in a rotating drum and impact of a particle on a particle bed. In all three cases, the standard formulation of the visco-elastic Hertz-Mindlin model for dry contacts was used and only spherical particles were modelled. The main goal of the performed study was to compare the different software systems and algorithms. This study did not aim to validate the DEM approach or to test the correctness of the contact model implementations. Thus, in addition to analysing the simulation results, we compared the performance of the DEM softwares: All three cases were run on a personal computer equipped with one CPU and one GPU. The obtained results should help new users to identify which software is most suitable for them and to increase overall confidence in open-source packages.
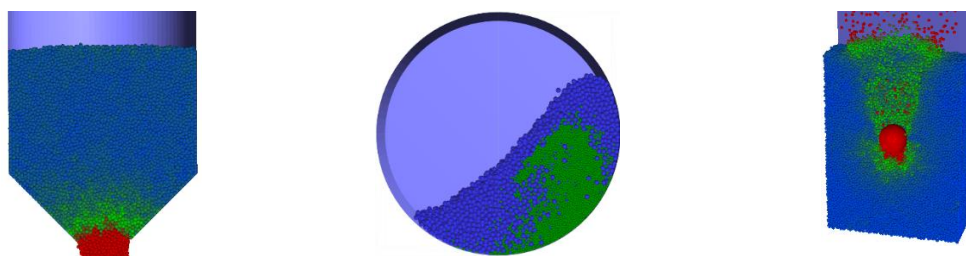
Fig. 1. Case studies investigated in the DEM benchmark.