Reducing the Computational Costs of CFD-DEM Simulations by Coupling Multiple Coarse Grain Levels

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ABSTRACT

The discrete element method (DEM), often combined with computational fluid dynamics (CFD), has proven to be a valuable tool for the analysis of granular flows. In a broad field of industries, DEM and CFD-DEM simulations are used for process optimization and equipment design. However, a major shortcoming of the DEM is its high computational demand, due to the tracking of each individual particle.

The coarse grain model of the DEM alleviates the hardware requirements, substituting multiple particles by one coarse grain, thus effectively reducing the number of particles involved in the calculations. However, the method fails for effects that intrinsically depend on grain size. This becomes problematic especially in large industrial facilities that consist of processes at multiple scales.

Striving for an adequate description of such large-scale systems, we have developed a method which couples multiple coarse grain levels to adjust the resolution of the simulation as needed. The coupling is established by exchanging volumetric properties of the granular flow to impose proper boundary conditions in each sub-region. In this way it is possible to preserve the particulars of the granular system in spatially confined regions and at the same time benefit from the gain in speed of the coarse grain model, where a lower level of detail is sufficient. On the CFD side, the mesh resolution can be chosen accordingly.

We have integrated our fully parallelized model into the LIGGGHTS and CFDEMcoupling open source framework. The method was validated through comparison of the statistical properties of fine-scale reference simulations with the properties of the corresponding multi-level coarse grain systems. The results showed very good agreement while the speedup achieved with our model was nearly proportional to the amount of saved particles.

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