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ON BOUNDARY APPROXIMATION FOR VOXEL-BASED SIMULATION OF GRANULAR FLOW

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The simulation of granular dynamics is an important task, not the least since granulates are used in most industrial processes. In many cases, inside view into the important parts of the production line is not possible. Optimization or a better understanding can, thus, be very difficult without the ability to simulate large parts of the process.

Particle-based simulation of granular material are limited in particle numbers by computation time and storage. This limit may be too small to simulate a complete production process. Furthermore, complex non-spherical and non-uniform particles pose difficult modeling challenges.

The continuum model [1] on the other hand, using a non-Newtonian compressible viscous Navier-Stokes-Equation, does not scale in run-time with the number of particles. Moreover, the granular properties required for the simulation, e.g. shear stresses, can obtained from physical experiments. Multiphase flows involving fluids are also possible.

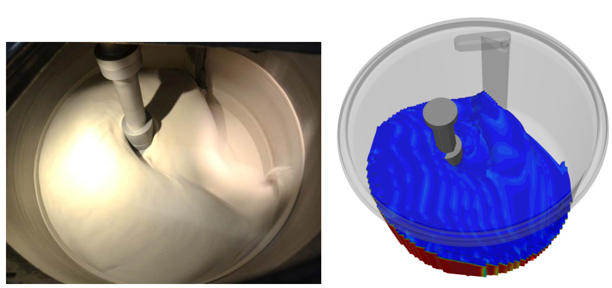

Figure 1: Fraunhofer ITWM, Maschinenfabrik Gustav Eirich GmbH, Full 3D simulation of Eirich Mixer PowTech, 2011.

Yet, designing robust methods for simulations of these equations on complicated geometries is not trivial. It is a common approach to choose a voxel grid, possibly with local refinement. Although this is being used quite successfully on arbitrary domains, a smooth boundary is discretized as a "stair"-like structure if the boundary is not parallel to the Cartesian grid.

The resulting error that may occur in extreme cases can be seen in Figure 2 on the left side. The density is compacted in some corners of the discretized circle. Due to the strong density dependence of the granular fluid properties, see i.e. [1], this leads to a strong accumulation, affecting the flow in the complete domain.

In order to obtain a consistent Cartesian grid method on a complicated domain it is beneficial to use some modification of the equations or the discretization at the boundary. These approaches are summarized under the label "Immersed Boundary Methods". The aim of my thesis is to develop an immersed boundary method that is applicable to the three dimensional macroscopic granular equations. We approach this by applying a Cartesian cut-cell method, similar to Hartmann et. al. [2], see [3]. A Voronoi interpolation is utilized, when values beyond the known cell-centers are required.

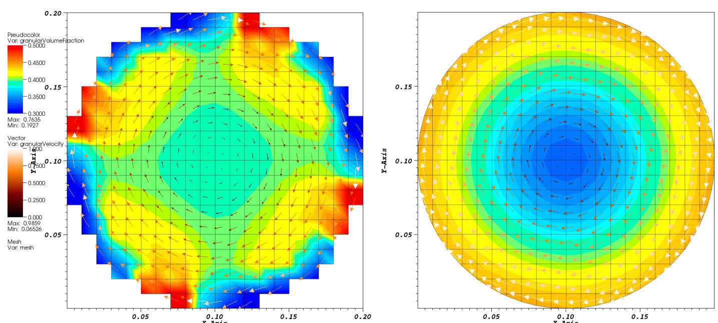

Figure 2: Extreme case of failure for pure voxel solver (left): Rotation of granular material induced by a uniform tangential velocity on a circular boundary. On the right side: The same example using the presented cut-cell method, yielding the expected result.

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