A Consistent Boundary Method for the Material Point Method – Using Image Particles to Reduce Boundary Artefacts

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ABSTRACT

The Material Point Method (MPM) is a continuum-based numerical method which discretises the object as material points. It is particularly well suited for and has shown great success in the community for large deformations. Even though it has been widely adopted, there are still fundamental questions to be addressed.

In MPM the material properties are carried on the material points and the dynamics is calculated on an overlaid grid. Afterwards, the material points are integrated according to the grid values using an explicit time integration scheme. The traditional boundary methods are applied on the grid values, such as setting the grid momentum to zero for grid nodes inside a fixed wall. This can cause artefacts in the stress as seen for an object in touch with the wall. These distort the stress multiple grid lengths into the object.

In this paper we propose a novel consistent boundary method to reduce these artefacts. The method is borrowed from electrostatics and makes use of so called image particles. With their help the desired values of the momentum field are created on both the grid and particles in a consistent way. We will also show an optimization that makes the explicit construction of mirror particles unnecessary.

The traditional boundary method and image particle method are then compared using numerical examples featuring stress induced by a simple shear and body forces.

These numerical examples show a significant reduction of boundary artefacts using the image particle method.

REFERENCES