Improved time scheme integration approach for dealing with semi analytical wall boundary conditions in SPARTACUS2D

Martin Ferrand, a, b Tutors: Dominique Laurence b and Benedict D. Rogers b

Ecole des Ponts Paritech, France, a School of Mech., Aero. & Civil Engineering, University of Manchester UK. E-mail: martin.ferrand@ponts.org

Smoothed Particles Hydrodynamics (SPH) is a Lagrangian meshless method potentially violent simulations such as a wave breaking, or a dam break where Eulerian method can be difficult to apply.

Dealing with wall boundary conditions is one of the most challenging parts of the SPH method and many different approaches have been developed among (i) repulsive forces such as Lennard-Jones one, which is efficient to give impermeable boundaries but leads to non-physical behaviours, (ii) fictitious (or ghost) particles which provide a better physical behaviour in the vicinity of a wall but are hard to define for complex geometries and (iii) semi-analytical approach such as Kulasegaram et al. (2004) which consists of renormalising the density field near a solid wall with respect to the missing kernel support area. The present work extends this methodology, where we use intrinsic gradient and divergence operators which ensure conservation properties.

This work will present three key advances:

- The time integration scheme used for the continuity equation requires particular attention, and as already mentioned by Vila (1999), we prove there is no point in using a dependence in time of the particles’ density if no kernel gradient corrections are added. Thus, by using a near-boundary kernel-corrected version of the time integration scheme proposed by Vila, we are able to simulate long-time simulations ideally suited for turbulent flow in a channel in the context of accurate boundary conditions.
- All boundary terms issued from the continuous approximation are given by surface summations which only use information from a mesh file of the boundary.
- In order to compute the kernel correction, Feldman and Bonet (2007) use an analytical value which is computationally expensive whereas Kulasegaram et al. (2004) and De Leffe et al. (2009) use polynomial approximation which can be difficult to define for complex geometries. We propose here to compute the renormalisation term of the kernel support near a solid with a time integration scheme, allowing us any shape for the boundary.

Below we plot the pressure field of a 2D dam break in a tank with a wedge for the Lennard-Jones repulsive force in (a), fictitious particles in (b), the present method in (c) and the new method with finer resolution in (d). We can thus conclude that the improvements made allow a better reproduction of the pressure field next to the solid boundaries.

Figure 1
Comparison of the pressure field for a dam break test case in a tank with a wedge for different boundary conditions.

References

