Remapping by combined intersection- and swept-based methods in 2D ALE simulations of single-material flows

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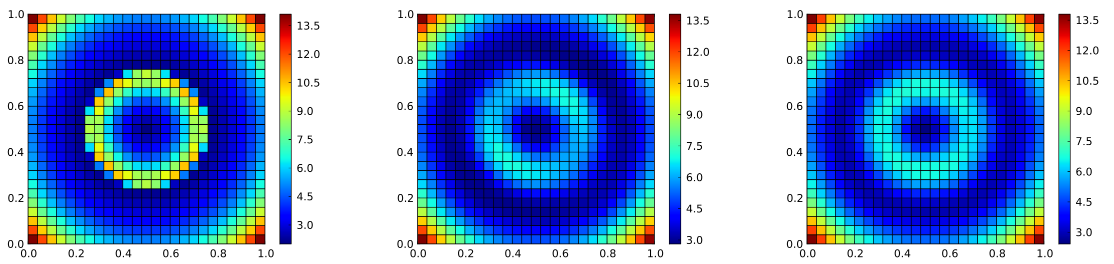
ABSTRACT

A typical Arbitrary Lagrangian-Eulerian (ALE) algorithm consists of a Lagrangian step, where the computational mesh moves with the fluid flow, a rezoning step, where the computational mesh is smoothed and repaired in case it gets too distorted, and a remapping step, where all fluid quantities are conservatively interpolated on this new mesh. In single-material simulations, the remapping process is often represented with fluxes constructed by integrating a reconstructed function over regions swept by edges of the computational cells. This method is robust and fast because the swept regions are formed from the old and new positions of cell vertices and therefore no polygon intersection calculation is needed. However, this method can produce inaccuracies if the mesh is moved in the direction of the cell corners during rezoning, distorting the symmetry of the quantities distribution (see Figure 1). An error with similar cause is also produced when the cell edge is rotated during rezoning (”hourglass” motion).

An alternative to the swept-based method is to integrate over the intersections of the computational cells. This approach requires a robust intersection algorithm, which is often more complex and expensive in terms of computational resources. Inspired by the hybrid algorithms combining both methods in multi-material simulations we propose a similar ”pseudo-hybrid” algorithm for single-material flows. Based on an error analysis, it employs exact intersections only in certain parts of the computational mesh, and the swept-based method is used elsewhere. This way our algorithm can retain the beneficial symmetry preserving capabilities of intersection remapping while keeping the overall computational cost moderate.



(a) Initial state (b) Swept-based method (c) Intersection-based method

Figure 1: Effect of a periodic diagonal mesh rezoning on a radially symmetrical density distribution.