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Moment-of-fluid interface reconstruction

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Volume-of-fluid (VoF) methods [2] are widely used in Eulerian simulations of multi-phase flows with mutable interface topology. The popularity of VoF methods is explained by their unique ability to preserves the mass of each fluid component on the discrete level. The strategy of VoF methods consists in calculating the interface location at each discrete moment of time from the volumes of the cell fractions occupied by different materials. Most VoF methods use a single linear interface to divide two materials in a mixed cell (Piecewise-Linear Interface Calculation (PLIC)) [3,4,5]. Once the direction of the interface normal is know, the location of the interface is uniquely identified by the volumes of the cells fraction. Unfortunately the interface normal can not be evaluated without the volume fraction data from the surrounding cells, which prohibits the resulting approximation to resolve any interface details smaller than a characteristic size of the cell cluster involved in evaluation of the normal. To overcome this limitation, we designed a new *mass-conservative* interface reconstruction metho [1], which calculates the interface based on both *volumes and centroids* of the cell fractions. This choice of the input data allows to evaluate the interface normal in a mixed cell *even without the information from the adjacent elements.* The location of the linear interface in each mixed cell is determined by *fitting the centroid of the cell fraction behind the interface to the reference one*, which leads to $(d-1)$-variate optimization problem in $\mathbb{R}^d$. The technique proposed, called Moment-of-Fluid (MoF) interface reconstruction, results in a *second order accurate* interface approximation (linear interfaces are reconstructed exactly), has higher resolution, and is shown to be *more accurate than VoF-PLIC methods.*

The centroid data involvement for the interface reconstruction has a clear mechanical justification. Any displacement $\Delta\mathbf{x}$ of the cell fraction centroid caused by the interface reconstruction can be interpreted as an action of an *artificial* force of magnitude $\sim m\Delta\mathbf{x}/\Delta t^2$ (here m is the mass of the cell fraction, and Δt is the time increment). Therefore by complying with the original centroids we *explicitly* reduce these artificial forces and improve approximation properties of the discrete model of fluid dynamics.

We present a detailed description of MoF interface reconstruction algorithm in

2D, which includes iterative procedure for centroid fitting and a new algorithm for cutting appropriate volume fractions from polygonal cells.

[1] V. Dyadechko and M. Shashkov. Moment-of-fluid interface reconstruction. Technical Report LA-UR-05-7571, Los Alamos National Laboratory, Los Alamos, NM, Oct 2005.

[2] C. W. Hirt and B. D. Nichols. Volume of fluid (VOF) method for the dynamics of free boundaries. *Journal of Computational Physics*, 39(1):201–25, Jan 1981.

[3] J. E. Pilliod and E. G. Puckett. Second-order accurate volume-of-fluid algorithms for tracking material interfaces. *Journal of Computational Physics*, 199(2):465–502, Sep 2004.

[4] B. Swartz. The second-order sharpening of blurred smooth borders. *Mathematics of Computation*, 52(186):675–714, Apr 1989.

[5] D. L. Youngs. An interface tracking method for a 3D Eulerian hydrodynamics code. Technical Report AWRE/44/92/35, Atomic Weapon Research Establishment, Aldermaston, Berkshire, UK, Apr 1987.