Out of the Comfort Zone

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The research story

Particle methods are a natural way of modelling flow problems. Particles can be seen as objects carrying a physical property of a system, following dynamics of a flow field. To assess an effectiveness and accuracy of a numerical method a following benchmark problem is considered. A sphere of a radius 0.15 and centre at (0.35, 0.35, 0.35) is placed inside a unit cube. The sphere is then deformed by a divergent-free flow field proposed in [1].

The image

The visualisation shows three stages of the sphere's deformation, with the initial state shown in the lower left corner, intermediate state in the middle and final deformed state in the upper right corner. After reaching the final state, the flow deforms the interface back to the initial sphere, following the shown deformed states in a reverse order. Since the deformation field is reversible, it is possible to evaluate the accuracy of a numerical method under complex conditions without knowing the analytical solution. For instance, incapability of the solver to reproduce the initial sphere indicates loss of the mass and dissipation of the method. The 3D visualisation is used to identify sources and locations of such errors. The present visualisation is performed in Volume Perception [2], a volume rendering software using a ray-casting technique. The field is visualised as translucent isosurfaces obtained by pre-integrated volume rendering.

References

[1] Leveque RJ, High-resolution conservative algorithms for advection in incompressible flow. SIAM Journal on Numerical Analysis 33(2):627–665, 1996.

[2] Rossinelli D, Multiresolution flow simulations on multi/many-core architectures, PhD thesis, ETH Zurich, 2011.

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