Computational techniques for stabilized edge-based finite element simulation of free-surface flows

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RESUMO

Free-surface flows occur in several problems in hydrodynamics, such as fuel or water sloshing in tanks, waves breaking in ships, offshore platforms, harbors and coastal areas. The computation of such highly nonlinear flows is challenging since free-surfaces commonly present merging, fragmentation and breaking parts, leading to the use of interface capturing Eulerian approaches embedded in ALE formulations.

In such methods the surface between two fluids is captured by the use of a marking function which is transported in a flow field. In this work we discuss computational techniques for efficient implementation of 3D incompressible SUPG/PSPG finite element methods to cope with free-surface problems with the Volume-of-Fluid (VOF) method. The pure advection equation for the scalar marking function was solved by a fully implicit parallel edge-based SUPG finite element formulation. Global mass conservation is enforced adding or removing mass proportionally to the absolute value of the normal velocity of the interface.

We introduce parallel edge-based data structures, a parallel dynamic deactivation algorithm to solve the marking function equation only in a small region around the interface. The implementation is targeted to distributed memory systems with multi-core processors. The performance and accuracy of the proposed solution method is tested in the simulation of a dam-break problem, the water impact on an obstacle and on a square cylinder and in the propagation of solitary and regular waves.