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An improved SPH model for water entry of free falling objects

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Summary

Water entry can be frequently observed in daily life and engineering and sciences. Typical examples include the entry of re-entry capsule of spacecrafts and submarine, landing of aircraft on water, and diving of sportsman. The phenomenon of water entry is of significant importance both in theory and practice. Numerical simulation of water entry problems is a formidable task and involves rapid movement and breakup of free surfaces, strong turbulence and vortex and violent fluid-solid interaction. Though conventional grid based methods like FDM, FVM and FEM have achieved greatly in computational fluid dynamics, there are still many difficulties in simulating water entry problems.

Smoothed particle hydrodynamics (SPH) is a popular meshfree, Lagrangian, particle method with some attractive features [1, 2]. SPH uses a set of freely moving particles to represent the state of a system and to approximate the governing partial differential equations, and therefore it can naturally treat moving features and does not need any interface/surface capture or tracking algorithm.

In this paper, we presented an improved SPH model for simulating water entry problems. The SPH model involves three major modifications on the traditional SPH method, 1) correction on the SPH kernel and kernel gradients to improve the computational accuracy in particle approximation, 2) RANS turbulence model to capture the inherent physics of flow turbulence, and 3) enhanced solid boundary treatment algorithm with pressure correction to remove fake pressure oscillation near solid boundaries. The improved SPH model has been used to simulate the water entry of two free falling objects, one is wedge and the other is a sphere. The effectiveness of the model has been verified by the good agreement of the SPH results and data from other sources.