PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
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A NUMERICAL STUDY OF WATER ENTRY PROBLEMS BASED ON OVERSET MESHES

By

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2PM CDT, Monday, December 13th, 2021

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Abstract

A series of numerical experiments carried out on the water entry of circular cylinders are presented in this study. The interface between water and air is tracked by the Piecewise Linear Interface calculation (PLIC) schemes in conjunction with the Volume of Fluid (VOF) method. Piecewise Linear Interface Calculation (PLIC) schemes have been extensively employed in the VOF method for interface capturing in numerical simulations of multiphase flows. Dynamic overset meshes, which have been widely used for problems with relative motions and complex geometric shapes, are applied to handle the moving cylinder. The numerical model is built on the framework of OpenFOAM which is an open-source C++ toolbox. The results of the numerical model, such as the transient positions and inclined angles of the moving circular cylinder, have been validated with experimental data in the literature. The fluid physics of the oblique water entry problem has been examined. The formation and development of the air entrapment have been explored. Parametric studies on the hydrodynamics of the water entry problem have been performed.

A difficulty of the overset mesh implantation in the PLIC-VOF method is the interpolation of the VOF field. A geometric interpolation scheme of the VOF field in overset meshes for the PLIC-VOF method has also been proposed in this thesis. The VOF value of an acceptor cell is evaluated geometrically with the reconstructed interfaces from the corresponding donor elements. Test cases of advecting liquid columns of different shapes inside a unit square/cube with a prescribed rotational velocity field have been performed to demonstrate the accuracy of the proposed overset interpolation scheme by comparing it with three algebraic ones. The proposed scheme has been shown to yield higher accuracy.