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ONE- AND TWO-PHASE SIMULATIONS OF DROPPING AND PLANING BOATS USING ADAPTIVELY REFINED GRIDS

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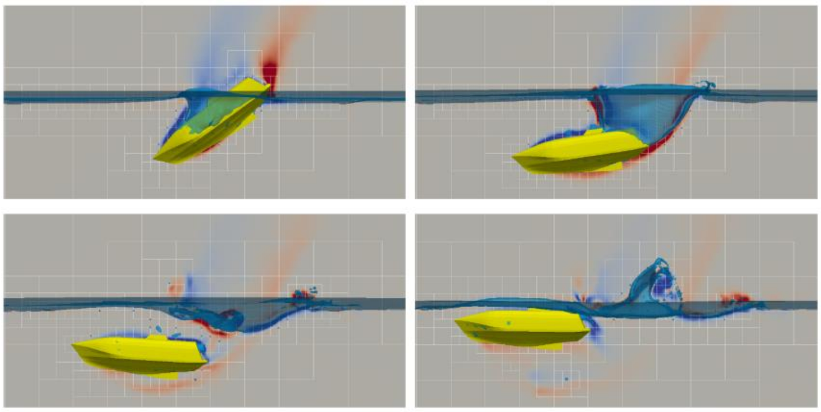
A commonly encountered offshore engineering application involves the calculation of wave impacts on (moving) structures, like sailing vessels. To obtain details of the surface dynamics and kinematics of (breaking) waves around complicated structures, one has to resort to simulation of the full Navier-Stokes equations on grids with sufficient resolution. In many complex problems such resolution can only be obtained by implementing some form of adaptive grid refinement, in which the grid resolution is only increased in areas where this is physically required.

The starting point for the work presented here is a second-order accurate and energy-conservative discretization of the flow equations on a structured, rectangular grid, as described in [1]. The immersed boundaries (free surface, solid objects) are accounted for by means of a Volume-of-Fluid method for the free surface [2] and a cut-cell discretization for the geometry [3].

A particular challenge is to accurately impose incoming waves and to reduce wave reflections at the outflow boundaries. This is achieved through generating and absorbing boundary conditions, based on a Sommerfeld condition. The novel feature is imposing a local solution-adaptive wave speed. It is found, through the dispersion relation, from the local wave number and the strength of an eventual current. The latter may also represent the boat speed (when using a moving coordinate system).



Grid resolution

is locally enhanced by means of a Cartesian block-based refinement approach, which allows for efficient grid adaptation with moderate overhead. An array-based data structure is employed, which exploits the semi-structured nature of the block grid. The discretization around refinement interfaces strives for mass- and momentum conservation, while limiting the amount of solution-disturbing artificial diffusion. The computational efficiency is enhanced by means of a hybrid MPI-OpenMP parallelization.

We have tested the method with one-phase simulations of a fast-sailing (planing) speedboat, and two-phase simulations of lifeboat drops in regular and irregular wave conditions.

REFERENCES

[1] R.W.C.P. Verstappen and A.E.P. Veldman, Symmetry-preserving discretization of turbulent flow. *J. Comput. Phys.*, Vol. **187**(1), pp. 343-368, 2003.
[2] K.M.T. Kleefsman, G. Fekken, A.E.P. Veldman, B. Iwanowski and B. Buchner, A Volume-of-Fluid based simulation method for wave impact problems. *J. Comput. Phys.*, Vol. **206,** pp. 363-393, 2005.
[3] M.T. Dröge and R.W.C.P. Verstappen, A new symmetry-preserving Cartesian-grid method for computing flow past arbitrarily shaped objects. *Int. J. Numer. Meth. Fluids,* Vol. **47**, pp. 979-985, 2005.