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FloatStepper: A robust rigid body-fluid coupling algorithm for OpenFOAM

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ABSTRACT

CFD is potentially a powerful tool for assessing floater-wave dynamics when designing floating offshore structures such as floating wind turbines. However, under some circumstances the so-called *added mass instability problem* can be a big nuisance, causing simulations to crash apparently out of nowhere. The problem is particularly pronounced when the body is much lighter than the surrounding fluid. In the widely used open source CFD code, OpenFOAM, the traditional remedy is to introduce underrelaxation of the calculated body acceleration, and outer correctors where both fluid and body motion are calculated multiple times within each time step (Huang *et al.*, 2022). This is computationally expensive, and stability is still not guaranteed. To overcome this problem, we device a new algorithm, dubbed FloatStepper, where we conceptually divide the forces on the floater into an added mass term and everything else, and then calculate each term separately before taking the actual CFD time step (Roenby *et al.*, 2024). This removes the root cause of the added mass instability, and we demonstrate with simple benchmarks that the solver works and is stable for arbitrarily low body mass. Finally, we demonstrate the capabilities of the solver in more realistic benchmarks involving a novel offshore wind floater design (Figure 1), and discuss current limitations and future improvements (Aliyar *et al.*, 2024).

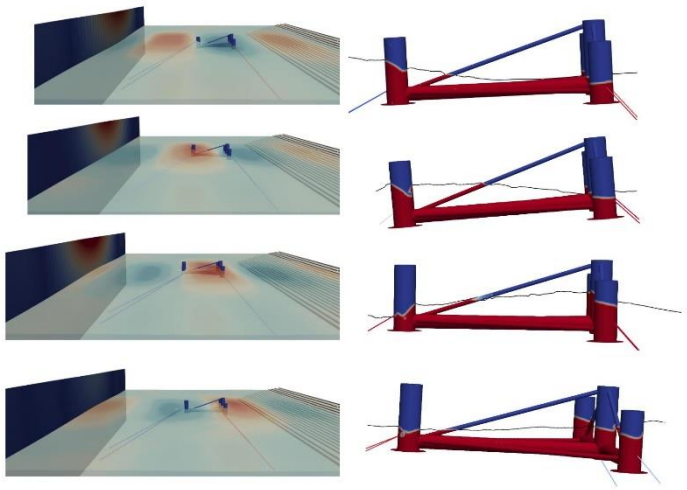

Figure 1: Four snapshots from numerical wave tank tests using FloatStepper for a focused wave hitting a design variant of Stiesdal Offshore's TetraSub wind turbine floater concept. Figure from (Aliyar et al., 2024).

References

Aliyar, S. *et al.* (2024) 'Robust CFD Analysis of Floating Wind Turbine Wave Responses With the FloatStepper Algorithm', in. *ASME 2024 43rd International Conference on Ocean, Offshore and Arctic Engineering*, American Society of Mechanical Engineers Digital Collection. URL: https://doi.org/10.1115/OMAE2024-128078.

Huang, L. *et al.* (2022) 'A Review on the Modelling of Wave-Structure Interactions Based on OpenFOAM', *OpenFOAM® Journal*, 2, pp. 116–142. URL: https://doi.org/10.51560/ofj.v2.65.

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