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A temporal coupling approach between a Navier-Stokes solver and a linear, time-domain model with application to wave energy converters

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Past failures demonstrate that the wave energy industry requires more sophisticated tools to accurately represent both the 6 degrees of freedom (6-DoF) motion and resulting mechanical loads on devices. Furthermore, these methods must be computationally efficient if they are to be utilised in routine design processes [1]. Wave energy converters (WECs) usually have large dynamic responses and are often composed of multiple interconnected components. This results in complex, and often highly nonlinear, device motion which depends heavily on past events [2]. This study aims to develop a numerical tool capable of predicting the nonlinear wave-WEC interactions over long time-periods with the minimum computational effort.

A numerical wave tank (NWT), utilising a Navier-Stokes (NS) solver and based on OpenFOAM-4.1, is coupled with a linear, time-domain model for multi-body dynamics – WaveDyn (developed by DNV-GL and based on the Boundary Element Method). To maximise efficiency, the coupling strategy utilises the computationally efficient method, WaveDyn, preferentially reserving the expensive NS solver for instances in which the linear assumptions of WaveDyn are violated [3]. The strategy has been termed 'temporal-coupling'. At these instances, data (surface-elevation and the 6-DoF motion state of the device) is passed from WaveDyn to the NS solver in order to perform a 'hot start' of the high fidelity model.

The two main issues relating to this 'hot start' are: 1) converting a linear description of the surface-elevation to a fully non-linear one (and vice versa), and; 2) implementing the device's 6-DoF motion state as an initial condition in the NWT. Using a linear superposition of wave components, the NS solver starts a couple of seconds prior to the hot-start time (depending on the non-linearity of the upcoming event). Furthermore, an initial mesh-deformation library has been created, in order to set the position of the buoy according to its hot-start position by deforming the original mesh (with the device at rest). The numerical results are compared against physical tank tests performed in the COAST Laboratory at Plymouth University [4].

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