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A Digital Twin Framework for Massively Parallel Simulations of Water Waves interacting with Large-Scale Offshore Structures

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Numerical computations of wave-wave and wave-structure interactions can be extremely costly and time-consuming when the simulations are large-scale (large domains and/or multiple complex bodies) and over long periods of time. Hence, it stresses the importance of numerical strategies that are efficient and scalable. This work focuses on implementing a massively parallel spectral element solver based on fully nonlinear potential flow models [1]. This solver constitutes the basis for a new Digital Twin simulation framework that will enable the simulation of offshore structures in a virtual environment. The framework aims to reproduce realistic sea state conditions and include offshore structures, such as floating wave energy devices and wind turbine structures. The long-term vision is to be able to support methods that allow the integration of sensor data in the modeling. The numerical backbone of the model is currently developed using the open-source high-order finite element framework, Firedrake [2], which supports the implementation of state-of-the-art finite element methods. The Firedrake software is designed to ease the steps from continuous governing equations to discretized systems and simulations. The spectral element method has been studied for wave and wave-structure simulations for over a decade at DTU Compute [1,3-4]. Ultimately, the proposed framework aims to resolve wave-related problems in full spatial dimensions (3D) of various levels of fidelity with emphasis on incompressible free surface flow modeling and floating offshore structures. The presentation will motivate the project's first results and showcase relevant advances in the ongoing implementations. The work is supported by COWIFonden (Grant A-165.19).

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