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Title: Real-time hybrid simulation of wave energy converter moorings: a virtual loop validation

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Wave energy converters (WECs) are advancing rapidly to support the global transition to renewable energy. This progress necessitates extensive small-scale testing of WEC components before open-ocean deployment. While hull designs can be readily scaled and tested in wave flumes, mooring lines present a greater challenge due to the difficulty of maintaining both hydrodynamic and structural properties at reduced scales. Currently, simulations are the only viable method for pre-deployment mooring testing.

To address this limitation, we propose a real-time hybrid simulation (RTHS) strategy that models full-scale mooring lines and applies their forces to a physical WEC in a wave flume. This approach enables the evaluation of mooring effects on WEC motion before full-scale deployment, potentially transforming WEC prototyping by reducing costs and development time.

The next phase of this research involves developing a virtual RTHS system, which must be validated before further advancement. In this virtual framework, we compare a fully simulated WEC with moorings to a fully simulated floating body with mooring forces applied via the RTHS system. The simulated model utilizes WEC-Sim and MoorDyn, open-source tools for WEC and mooring simulations, respectively. Meanwhile, the RTHS system employs WEC-Sim for floating body dynamics while computing mooring forces separately. This comparison will identify potential errors and latency effects in force calculation and communication within the RTHS loop.

On a larger scale, this research provides a preliminary validation of the RTHS system, this work aims to identify and mitigate potential issues before physical experimentation, ensuring a more efficient and cost-effective path toward full-scale implementation.

*Keywords – Real-time hybrid simulation, hardware-in-the-loop, wave energy converter, validation, WEC-Sim, MoorDyn, Mooring*