High-resolution SPH modeling of fluid-structure interaction: application to WEC design

Morteza Derakhti1, Jim Thomson1,2, Brian Polagye1,2, Brittany Lydon2

1. Applied Physics Laboratory, University of Washington, 2. Department of Mechanical Engineering, University of Washington

SPH modeling of fluid-structure interaction

- Smoothed Particle Hydrodynamics (SPH), is a mesh-free, Lagrangian method for CFD modeling
- The computational domain is discretized in a set of particles (Figure 1)
- Each particle carries scalar and vector properties (mass, density, position, velocity, etc)
- Each particle satisfies equations of continuity and motion

Application to WEC design

- Coupled GPUSPH-Chrono model is an efficient high-resolution modeling system for
  - modeling
  - design
  - optimization of WECs in realistic sea states.

GPUSPH Model

- GPUSPH is an open-source implementation of the SPH method on Graphics Processing Units (GPU) by using NVIDIA CUDA (www.gpusph.org):
  - Weakly compressible SPH
  - Turbulence resolving with LES resolution: SPS viscosity
  - Dynamic particle boundaries
  - Homogeneous accuracy (Hérault et al., 2014)
  - CUDA C++, Multi-node, multi-GPU

GPUSPH-Chrono Coupling

- GPUSPH computes the fluid motion, and further calculates the force exerted on the object (e.g., WECs)
- Chrono solves the object dynamics equations to determine the position of the WECs (Figure 2)

Realistic Hydrodynamic Forcing

- GPUSPH has been successfully used for studying short-crested breaking waves and nearshore circulation

Multi (flexible) objects + PTO

- Recent simulations using Coupled GPUSPH-Chrono model

Funding Sources

PMEC Member Universities

Figure 1: Discretization of a domain with SPH particles

Figure 2: GPUSPH-Chrono coupling (Wei et al. 2019)

Figure 3: Example of large type WEC Devices (Waveroller)

Figure 4: Examples of GPUSPH simulations of nearshore wave breaking and circulation (Jalali Farahani et al. 2014, Derakhti et al. 2019)

Figure 5: GPUSPH-Chrono model-data comparison of an interaction of a moving object with regular waves (Wei et al. 2019)