Research Goal

To design and develop Chrono::HPC, a distributed memory framework for large-scale fluid-solid interaction simulations.

Fluid Model

- Smoothed Particle Hydrodynamics (SPH).
- Runge-Kutta 2\textsuperscript{nd} Order.
- Wall Boundary with Boundary Condition Enforcing (BCE) markers (Figure 6).
- Periodic Boundary Condition (Figure 1)

Parallel Model

- Charm++ Parallel Programming Framework/Paradigms: Over decomposition, migratability, and message-driven execution.
- Hybrid decomposition: Spatial + Force decomposition. Inspired by NaMD.
- Cell/Bin Chare: Contains data. Takes care of force reduction, time integration and particle migration to neighbor cells.
- Compute Chare: Compute interactions within a Cell or between neighbor cells.

Experiments and Results

- Dam Break Simulations

![Figure 3: Dam break simulation (139,332 SPH Markers).](image)

- Hyper Parameter Search

![Figure 4: Hyper parameter search for optimal cell size and Charm++ nodes per physical node. Nodes denotes physical nodes (64 processes per node), and \( h \) denotes the particle interaction radius.](image)

- Scaling Analysis

![Figure 5: Speeups calculated with respect to an 8 processors run. Left: Scaling analysis from 8-504 processors. Right GPU speedups.](image)

References


Future Work

- Generalized Wall Boundary Condition (Improve Stability and Accuracy).
- Further scaling analysis and comparison with MPI codes.
- Fluid-Solid Interaction leveraging Chrono.

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