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IAMReX: an adaptive framework for the multiphase flow and fluid-particle interaction problems

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Summary

IAMReX is an adaptive C++ solver designed for multiphase flow and fluid-particle interaction problems. It is built in a objected-oriented style and capable of high-performance massively parallel computing complex systems (e.g., gas-fluid interaction, cluster of particles).

The original goal of IAMReX is to extend the capability of IAMR code (Almgren et al., 1998), which only uses a density-based solver to capture the diffused interface of the two-phase flow. IAMReX offers the Level Set (LS) method and the reinitialization techniques for accurately capturing the two-phase interface (Zeng et al., 2022), which increases the robustness of simulations with high Reynolds number (Zeng et al., 2023). For fluid-particle interaction problems, IAMReX employs the multidirect forcing immersed boundary method (Li et al., 2024). The associated Lagrangian markers used to resolve fluid-particle interface only exist on the finest-level grid, which greatly reduces memory cost. Both the subcycling and non-subcycling time advancement methods are implemented, and these methods help to decouple the time advancement at different levels. In addition, IAMReX is a publicly accessible platform designed specifically for developing massively parallel block-structured adaptive mesh refinement (BSAMR) applications. The code now supports hybrid parallelization using either pure MPI or MPI & OpenMP for multicore machines with the help of the AMReX framework (Zhang et al., 2019).

The IAMReX code has undergone considerable development since 2023 and gained a few new contributors in the past two years. Although the projection-based flow solver is inherited from IAMR, IAMReX has added over 3,000 lines of new code, introduced 10 more new test cases, and contributed approximately 60 new commits on GitHub. The versatility, accuracy, and efficiency of the present IAMReX framework are demonstrated by simulating two-phase flow and fluid-particle interaction problems with various types of kinematic constraints. We carefully designed the document such that users can easily compile and run cases. Input files, profiling scripts, and raw postprocessing data are also available for reproducing all results (Liu et al., 2024).

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