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A highly efficient sharp-interface immersed boundary method with adaptive mesh refinement for bio-inspired flow simulations.[1] XIAOLONG DENG, HAIBO DONG, University of Virginia — Developing a high-fidelity, high-efficiency numerical method for bio-inspired flow problems with flow-structure interaction is important for understanding related physics and developing many bio-inspired technologies. To simulate a fast-swimming big fish with multiple finlets or fish schooling, we need fine grids and/or a big computational domain, which are big challenges for 3-D simulations. In current work, based on the 3-D finite-difference sharp-interface immersed boundary method for incompressible flows (Mittal et al., JCP 2008), we developed an octree-like Adaptive Mesh Refinement (AMR) technique to enhance the computational ability and increase the computational efficiency. The AMR is coupled with a multigrid acceleration technique and a MPI+OpenMP hybrid parallelization. In this work, different AMR layers are treated separately and the synchronization is performed in the buffer regions and iterations are performed for the convergence of solution. Each big region is calculated by a MPI process which then uses multiple OpenMP threads for further acceleration, so that the communication cost is reduced. With these acceleration techniques, various canonical and bio-inspired flow problems with complex boundaries can be simulated accurately and efficiently.

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