A scalable Lagrangian particle tracking method

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ABSTRACT

Particle tracking within an underlying flow field is routinely used to analyse both industrial processes and natural phenomena. In a computer code running on a distributed-memory architecture, the different behaviour of fluid-particle systems must be taken into account to properly balance element-particle subdivision among processes. In unsteady simulations, the parallel efficiency is even more critical because it changes over time. Another challenging aspect of a scalable implementation is the initial particle location due to the arbitrary shapes of each subdomain.

In this work, an innovative parallel ray tracing particle location algorithm and a two-constrained domain subdivision are presented. The former takes advantage of a global identifier for each particle, resulting in a significant reduction of the overall communication among processes. The latter is designed to mitigate the load unbalance in the particles evolution while maintaining an equal element distribution. A preliminary particle simulation is performed to tag the cells and compute a weight proportional to the probability to be crossed. The algorithm is implemented using MPI distribute memory environment. A cloud droplet impact test case starting from an unsteady flow around a 3D cylinder has been simulated to evaluate the code performances.

The tagging technique results in a computational time reduction of up to 78% and a speed up factor improvement of 44% with respect to the common flow-based domain subdivision. The overall scalability is equal to 1.55 doubling the number of cores.

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