GPGPU implementation of a lattice Boltzmann methodology for particle transport and deposition in complex flow

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Abstract

Purpose – This study aims to modify the standard probabilistic lattice Boltzmann methodology (LBM) cellular automata (CA) algorithm to enable a more realistic and accurate computation of the ensemble rather than individual particle trajectories that need to be updated from one time step to the next (allowing, as such, a fraction of the collection of particles in any lattice grid cell to be updated in a time step, rather than the entire collection of particles as in the standard LBM-CA algorithm leading to a better representation of the dynamic interaction between the particles and the background flow). Exploitation of the inherent parallelism of the modified LBM-CA algorithm to provide a computationally efficient scheme for computation of particle-laden flows on readily available commodity general-purpose graphics processing units (GPGPUs).

Design/methodology/approach – This paper presents a framework for the implementation of a LBM for the simulation of particle transport and deposition in complex flows on a GPGPU. Towards this objective, the authors have shown how to map the data structure of the LBM with a multiple-relaxation-time (MRT) collision operator and the Smagorinsky subgrid-scale turbulence model (for turbulent fluid flow simulations) coupled with a CA probabilistic method (for particle transport and deposition simulations) to a GPGPU to give a high-performance computing tool for the calculation of particle-laden flows.

Findings – A fluid-particle simulation using our LBM-MRT-CA algorithm run on a single GPGPU was 160 times as computationally efficient as the same algorithm run on a single CPU.

Research limitations/implications – The method is limited by the available computational resources (e.g. GPU memory size).

Originality/value – A new 3D LBM-MRT-CA model was developed to simulate the particle transport and deposition in complex laminar and turbulent flows with different hydrodynamic characteristics (e.g. vortex shedding, impingement, free shear layer, turbulent boundary layer). The solid particle information is encapsulated locally at the lattice grid nodes, allowing for straightforward mapping of the datastructure onto a GPGPU enabling a massive parallel execution of the LBM-MRT-CA algorithm. The new particle transport

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