Lattice Boltzmann Simulations Coupled with Octree-based Locally-refined Mesh using Space-filling Curves

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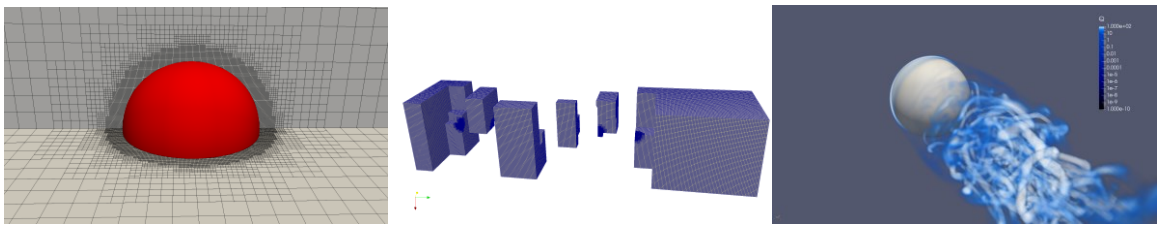
ABSTRACT

For aerodynamics simulations using GPUs, we employ the lattice Boltzmann method (LBM), because the method is a kind of stencil calculations with the simple algorithm and has high locality for memory access. We implement the D3Q27 model with the multiple relaxation time (MRT) integration [1] to improve stability and accuracy and make a code in CUDA. In addition, we introduce an octree-based locally-refined mesh method and assign high resolution region near the boundary of complex bodies. For tuebulent flows, we apply large eddy simulation (LES) using coherent-structure Smagorinsky model (CSM) [2] which is able to determine the model coeddicient locally. For multiple GPU computing, Hilbert space-filling curve is used to decompose the computational domain, and more than one different space-filling curves are used when the whole computational domain is not cubic shape. Figure 1 shows the flow computation around a sphere which our method has been applied to.



(a) (b) (c)

Fig. 1: A flow simulation around a sphere. (a) Mesh refinement near the sphere. (b) Domain decomposition. (c) Computational result for the second variance of the velocity gradient tensor with Reynolds number 3,000.

REFERENCES

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[2] H. Kobayashi, "The subgrid-scale models based on coherent structures for rotating homogeneous turbulence and turbulent channel flow", *Physics of Fluids*, Vol. **17**, No. 045104 (2005)