Simulation of 2-dimensional flows in Modelica with the Casacaded Digital Lattice Boltzmann Method

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Calculating the dynamics of fluid flows is an important topic in the field of simulation. Common practice is to simulate complex scenarios by utilizing Computational Fluid Dynamics (CFD). Despite its capability of representing fluid flows in a very detailed way it has the drawback of compatibility. Coupling with other physical domain simulations is only possible by co-simulation. In this contribution a general methodology for modeling 2D fluid flows in Modelica is shown. Whereas there are contributions were the Navier-Stokes equations are solved by a finite volume method, this work deals with modeling them with a Lattice Boltzmann Method.

The Lattice Boltzmann method (LBM) is a relatively new simulation technique for fluid systems that has attracted interest as alternative to the discretization of the Navier-Stokes equations. LBM is a mesoscopic approach for modeling macroscopic fluid dynamics based on the Boltzmann kinetic equation which describes the statistical behavior of a non-equilibrium thermodynamic system. The fluid motion is based on the collective dynamics of fictitious particles on the nodes of a regular lattice. The dynamics of these particles is designed to obey the basic conservation laws ensuring hydrodynamic behavior in the continuum limit.

In this paper the theory behind LBM and the modeling approach is described. The implementation in Modelica is shown and some examples are given. Finally a convenient approach for setting up the computational domain is shown.

References