OpenLB -- Fluid Flow Simulation and Control on High Performance Computers

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Abstract

An overall strategy for numerical simulations and optimization of fluid flows is introduced. The integrative approach takes advantage of numerical simulation, high performance computing (HPC) and newly developed mathematical optimization techniques, all based on a mesoscopic model description and on Lattice Boltzmann Methods (LBM) as discretization strategies [1]. The resulting algorithms were implemented in a highly generic way in the open-source framework OpenLB [2]. In the talk, particular focus is placed on the systematic approach of facing contemporary challenges in Computational Fluid Dynamics (CFD) [3, 4]. Further, the consideration of LBM as a generic technique for the approximation of Partial Differential Equations (PDE) [5] and its implementation on heterogeneous HPC-platforms are highlighted. The presented approaches and realizations are illustrated by means of various fluid flow simulation and optimization examples, where specific aspects are discussed for the simulation of turbulent flows [6].

Biography

Mathias J. Krause studied mathematics with economics at the Universität Karlsruhe (TH) in Germany and the Cardiff University in Wales. He graduated in 2006. Afterwards, he joined the Institute of Applied and Numerical Mathematics (IANM) at the Karlsruhe Institute of Technology (KIT). In 2010, he received a doctorate with his thesis on fluid flow control and optimization. Since April 2013, he heads the interdisciplinary Lattice Boltzmann Research Group (LBRG) at KIT. His research interests are mainly dedicated to the fields of applied mathematics, applied computer science with focus on HPC, CFD and optimization under the constraints of PDE. He is initiator and main author of OpenLB. His work was honored with several prizes and a membership as WIN-Kollegiat at the Heidelberg Academy of Science.

References

[1] Krause, M.J., 2010. Fluid Flow Simulation and Optimisation with Lattice Boltzmann Methods on High Performance Computers - Application to the Human Respiratory System, url: https://publikationen.bibliothek.kit.edu/1000019768.
[2] Krause, M.J., Kummerländer, A., Avis, S.J., Kusumaatmaja, H., Dapelo, D., Klemens, F., Gaedtke, M., Hafen, N., Mink, A., Trunk, R. and Marquardt, J.E., 2020. Openlb—Open source lattice Boltzmann code. *Computers & Mathematics with Applications*, doi: 10.1016/j.camwa.2020.04.033.
[3] Slotnick, J., Khodadoust, A., Alonso, J., Darmofal, D., Gropp, W., Lurie, E. and Mavriplis, D., 2014. CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences, *NASA Technical Report*, no. NASA/CR-2014-218178, url: https://ntrs.nasa.gov/citations/20140003093.
[4] Kwak, D., Kiris, C. and Kim, C.S., 2005. Computational challenges of viscous incompressible flows. *Computers & Fluids, 34*(3), pp.283-299, doi: 10.1016/j.compfluid.2004.05.008.
[5] Simonis, S., Frank, M. and Krause, M.J., 2020. On relaxation systems and their relation to discrete velocity Boltzmann models for scalar advection–diffusion equations. *Philosophical Transactions of the Royal Society A, 378*(2175), p.20190400, doi: 10.1098/rsta.2019.0400.
[6] Haussmann, M., Ries, F., Jeppener-Haltenhoff, J.B., Li, Y., Schmidt, M., Welch, C., Illmann, L., Böhm, B., Nirschl, H., Krause, M.J. and Sadiki, A., 2020. Evaluation of a Near-Wall-Modeled Large Eddy Lattice Boltzmann Method for the Analysis of Complex Flows Relevant to IC Engines. *Computation, 8*(2), p.43, doi: 10.3390/computation8020043.