Paper reviews

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December 9, 2022

1 URANOS: a GPU accelerated Navier-Stokes solver for compressible wall-bounded flows

1.1 Context

- Solver for high-fidelity modeling of comopressible wall flows
- Massively parallel GPU-accelerated
- Based on modern highfidelity and high-resolution discretization strategies for time-accurate compressible flow predictions
- Provides
  - 6 different convective scheme implementations
  - a cutting-edge method for viscous terms treatment
  - 3 different frameworks for turbulence modeling (DNS, LES, WMLES)
  - A high-order FD approach (from 2nd -¿ 6^{th} order spatial accuracy)
- Combines multiple 3D MPI parallelization strategies with the open standard, OpenACC, f or machine wide, on node, and on GPU parallelism

1.2 Numerical methods

- High-Order FD approach matching for both uniform and non-uniform Cartesian structures
- 6 different convective schemes
  - A central, zero-dissipative, 6^{th} order fully-split convective Energy-Preserving (EP) method to deal primarily with shock-free or smooth flows
  - 3 increasingly high-order WENO mehtods
  - 2 low-dissipative Targeted Essentially Non-Oscillatory (TENO) approaches.
- Shock-capturing method

1.3 Acceleration

- GPU porting
- Different approaches vary in terms of their degrees of portability, adaptability and computational performance
- Things to consider: the initial cost fo code development & the long term maintenance costs
- Better to have a single code base which targets different architectures
- Rather than programming with vendor-specific languages, the programmer can focus on accelerate in a vendor-neutral manner.
- The compiler transforms directives into device-specific application code.

1.3.1 OpenACC & MPI

- H2D/D2H data movements reduced as much as possible
- `parallel` construct is preferrred rather than `kernels` as it allows the user more control.
- And it enables controlling the loop granularity through the clauses (loop, ...)
  - Coarse-grained parallelism (*gang*)
  - Fine-grained parallelism (*worker*)
  - Single Instruction Multiple Data level (*vector*)
- `collapse` clause allow unifying all the iteration of nested loops in a single one
- MPI: the standard for inter-node data transfers
- Transition to a multi-GPU logic is not straightforward and hardware-unrelated.

1.4 Discussion