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Special Guest Lectures

Application of Cartesian SAMR for Real-World CFD

Ralf Deiterding
Center for Advanced Computing Research
Johnston Hall 338
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Abstract:
Finite-volume-based shock capturing schemes are the most appropriate numerical methods for computational fluid dynamics (CFD) of compressible high speed flows. Very high order discretizations are nowadays available, but achieving the theoretical possible order of convergence can be very cumbersome or even impossible on unstructured meshes. On the other hand, structured (Cartesian) methods are only applicable to simple geometries and cannot directly be employed for most CFD questions arising in science and engineering. In this talk, I present an approach in utilizing Cartesian schemes for real-world problems that combines the ghost-fluid idea with block-structured adaptive mesh refinement (SAMR). A scalar level set function storing the distance information to the boundary surface is used to consider arbitrary geometries on the Cartesian mesh without ambiguities. Minor approximation inaccuracies near the embedded boundary are alleviated by increasing the local resolution non-uniformly. Although the boundary consideration throughout the method is first-order for now, various two- and three-dimensional examples will be presented which demonstrate that the utilization of dynamic mesh adaptation makes the overall approach sufficiently accurate for serious computational investigations. Among the examples shown are shock simulations in converging geometry, fully resolved detonation waves in realistic experimental devices, and shock-driven compressible turbulent mixing. The method has been implemented in form of a generic, discretization-independent fluid solver framework and is part of the Virtual Test Facility by the Center for Simulating the Dynamic Response of Materials at the California Institute of Technology [1]. A temporal splitting algorithm will be described that couples the adaptive Eulerian finite volume method to Lagrangian finite element schemes for computational solid dynamics. The extension of the recursive SAMR algorithm after Berger and Collela for this problem class will be sketched. Three-dimensional fluid-structure interaction simulations involving large plastic deformations or fracture and fragmentation of thin flexible shells will be shown that confirm the applicability of the proposed techniques to problems with heavily evolving topology [2]. The implementation on platforms with distributed memory and software engineering aspects will be discussed.

Speaker's Bio:
Research Interests: * Innovative numerical methods for computational fluid dynamics. * Parallel hierarchical mesh refinement algorithms. * Object-oriented concepts for large simulation infra-structures. since Oct 04 Chief software architect for the Virtual Test Facility (VTF), a software infrastructure for three-dimensional fully coupled fluid-structure simulations. AMROC is the dynamically adaptive fluid-solver framework inside of the VTF. since Jul 03 Senior Postdoctoral Scholar in Applied and Computational Mathematics DOE ASCI Center for Simulating the Dynamic Response of Materials at the California Institute of Technology Feb 98-Jun 03 Research scientist at the chair for Numerical Mathematics and Scientific Computing, Technical University Cottbus, Germany. PhD thesis: Parallel adaptive simulation of multi-dimensional detonation structure Oct 92-Jan 98 Study of Applied Mathematics at Technical University Clausthal, Germany. Diploma thesis: Numerical coupling of the 3D flow-code FIRE to the 1D hydraulic-code AMESIM for the design of Diesel-injection systems