PARALLELISATION OF MULTISCALE-BASED GRID ADAPTATION USING SPACE-FILLING CURVES *

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Abstract. The concept of fully adaptive multiscale finite volume schemes has been developed and investigated during the past decade. By now it has been successfully employed in numerous applications arising in engineering. In order to perform 3D computations for complex geometries in reasonable CPU time, the underlying multiscale-based grid adaptation strategy has to be parallelised via MPI for distributed memory architectures. In view of a proper scaling of the computational performance with respect to CPU time and memory, the load of data has to be well-balanced and communication between processors has to be minimised. This has been realised using space-filling curves.

Key Words: Finite volume schemes, multiscale-based grid adaptation, parallelisation, load-balancing, space-filling curves.

AMS Classification: 65W05, 65Y05, 68Q22, 76M12.

Introduction

The numerical simulation of (compressible) fluid flow requires highly efficient numerical algorithms which allow for a high resolution of all physical waves occurring in the flow field and their dynamical behaviour. In order to use the computational resources (CPU time and memory) in an efficient way, adaptive schemes are well-suited for this purpose. By these schemes, the discretisation is locally adapted to the variation of the flow field. The crucial point in the adaptation process is the design of a criterion by which to decide whether to refine or to coarsen the grid locally.

In recent years, a new adaptive concept for finite volume schemes, frequently applied to the discretisation of balance equations arising for instance in continuum mechanics, has been developed based on multiscale techniques. First work in this regard has been published by Harten [23, 24]. The basic idea is to transform the arrays of cell averages associated with any given finite volume discretisation into a different format that reveals insight into the local behaviour of the solution. The cell averages on a given highest level of resolution (*reference mesh*) are represented as cell averages on some coarse level, where the fine scale information is encoded in arrays of *detail coefficients* of ascending resolution.

In Harten's original approach, the multiscale analysis is used to control a hybrid flux computation by which CPU time for the evaluation of the numerical fluxes can be saved, whereas the overall complexity is not reduced but still stays proportional to the number of cells on the uniformly fine reference mesh. Opposite to this strategy, threshold techniques are applied to the multiresolution decomposition in [12,29], where detail coefficients below a threshold value are discarded. By means of the remaining significant details, a locally refined mesh is determined whose complexity is substantially reduced in comparison to the underlying reference mesh.

The fully adaptive concept has turned out to be highly efficient and reliable. So far, it has been employed with great success in different applications, e.g., 2D/3D–steady and unsteady computations of compressible fluids around airfoils modelled by the Euler and Navier–Stokes equations, respectively, on block–structured curvilinear grid patches [9], backward–facing step on 2D triangulations [13] and simulation of a flame ball

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