An Improved Data Mapping Scheme for a Cell-Based Adaptive Mesh Refinement Solver

Jian Fang*, Charles Moulinec*, Umair Ahmed†, Girish Nivarti‡, Stewart Cant‡, Nilanjan Chakraborty†, David R Emerson*

* Scientific Computing Department, STFC Daresbury Laboratory, Warrington WA4 4AD, UK
e-mail: jian.fang@stfc.ac.uk

† School of Engineering, Newcastle University, Newcastle-Upon-Tyne, NE17RU, UK
e-mail: Umair.Ahmed@newcastle.ac.uk

‡ Engineering Department, Cambridge University, Trumpington Street, CB2 1PZ, UK
e-mail: gvn22@cam.ac.uk

ABSTRACT

A cell-based adaptive mesh refinement (AMR) solver HAMISH code is currently under development for turbulent retracting flows. The numerical framework relies on a finite-volume approach for spatial discretisation together with an unstructured AMR Cartesian mesh, which allows adaptive local cell refinement and derefinement operations. The data structure is built by representing the unstructured mesh as a bitree/quadtree/octree and spanning the tree leaves with the help of the Morton code space filling curve [1], allowing efficient cell addressing and parallel domain decomposition.

The numerical schemes for calculating the flux at a cell's face and the gradient at a cell's centre are investigated for one-dimensional and two-dimensional linear wave propagation problems. It is found that the conventional second-order central scheme for uniform mesh induces wiggles at transitional cells, and the implementation of a numerical scheme for non-uniform mesh [2] for both gradient and flux can largely improve the result.

The data mapping schemes for cell refinement is also studied. The centre-gradient-based data mapping and face-gradient-based data mapping are compared. It is found that the centre-gradient-based data mapping ensures the conservation of field variables during cell refinement and derefinement, although it induces wiggles on discontinuities. The face-gradient-based data mapping can overcome the wiggles at discontinuities, but it cannot ensure the conservation property. Based on this analysis, a new centre-gradient-based refinement is proposed, where the gradient is calculated based on the minmod limiter of gradients at a cell's centre and faces, and it is found that the new data mapping method can satisfy both the conservation property during refinement and the non-oscillation property at discontinuities.

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