Development of an agglomeration multigrid technique in the hybrid solver elsA-H

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Abstract: This paper presents validation results for an agglomeration multigrid procedure developed in the context of hybrid grids. The grid coarsening technique relies on the agglomeration of cells based on their distribution on octree data structure. The used hybrid solver is called *elsA-H* and its aim is to leverage the full potential of structured solvers and unstructured mesh generation by enabling any type of grid to be used within the same simulation process. The aim of this work is, therefore, to accelerate *elsA-H* solver by implementating multigrid concept.

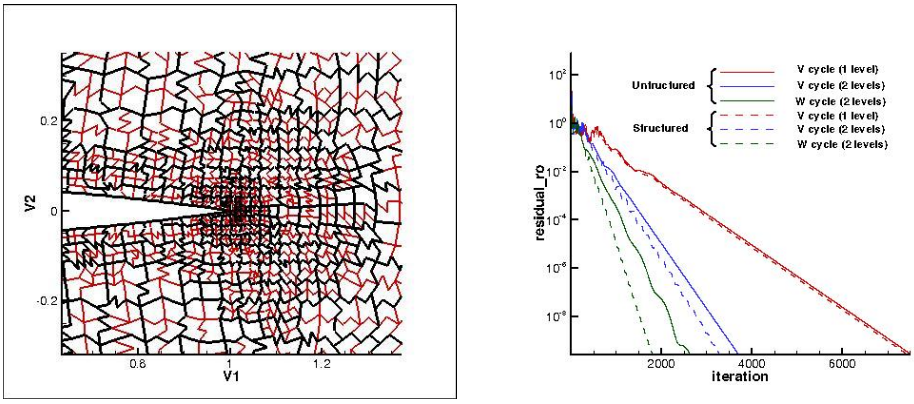
Keywords: Multigrid, finite volume method, unstructured grids.

Over the past few years, ONERA has been working on the extension of the multiblock structured solver *elsA* to hybrid grid configurations. The new hybrid solver is called *elsA-H*, in which a new unstructured solver has been built by taking advantage of the modular approach provided by the object-oriented framework. The aim of *elsA-H* is therefore to leverage the full potential of structured solvers and unstructured mesh generation by enabling any type of grid to be used within the same simulation process. The main challenge lies in the numerical treatment of the hybrid-grid interfaces where two different blocks meet. This paper reports recent progress on the development of a multigrid (MG) algorithm for unstructured grid simulations using *elsA-H*. This constitutes the first step towards the development of a more general hybrid MG technique, within the framework of the *elsA-H* project.

MG methods are based on the discretization of the equations onto a number of grids at different levels of resolution. The targeted solution to the equations is assumed to be well represented on the finest grid, whereas the rest of the grids provide a coarser approximation of the same solution, and are used to accelerate the overall convergence of the simulation process.

In the context of unstructured methods, a major difficulty of the MG technique lies in the generation of the coarse levels. The strategy adopted here is based on unstructured volume-agglomeration to generate the coarse levels from the fine grid. The developed algorithm is similar to the one used in *elsA*'s structured method [1], in which the grid transfer operators have been adapted to the unstructured framework.

The methodology used in the generation of the coarse grids is that developed by Mahmutyazicioglu [2]. The method relies on the agglomeration of cells based on teir distribution on octree data structure and consists of the following steps. A parallelepiped (rectangle in 2D) is defined to contain the whole computational domain. Then, thanks to an octree algorithm (quadtree in



(a) Two coarse levels

(b) Evolution of the L^2 residuals.

Figure 1: Unstructured MG simulation of the flow past a NACA 0012 airfoil.

2D) the domain is decomposed into octants (quadrants in 2D), containing a specified number of cells of the previous finer mesh. Fig. 1(a) shows two grid levels obtained by application of this approach to a triangular mesh of the NACA 0012 airfoil generated using Delaunay triangulation.

In order to be consistent with *elsA-H*'s face-based format, the connectivity information that defines the different grids is stored into the CGNS input file following this same data structure. The generation of the coarse grids is therefore considered as a pre-processing step in the simulation process.

The unstructured MG algorithm has been tested on several 2D quadrilateral meshes, so that the unstructured solution can be compared to that of the structured MG solver. The original structured grid is composed of 8192 cells (257×33). Fig. 1(b) compares the residuals obtained from the inviscid simulation of a 2D NACA 0012 airfoil using the structured and unstructured solvers respectively. The flow conditions correspond to transonic inviscid flow at Mach number 0.85 and angle of attack of 1^o. The simulation was run using Roe's scheme and Runge-Kutta time-stepping.

Note that when a single coarse level is used the behaviour of both solvers is essentially the same. The differences between both solvers then increase when two levels are considered, and in particular when the w-cycle algorithm is used. Despite the simplifications adopted in the unstructured method, these preliminary results demonstrate the overall good performance of the newly implemented MG unstructured solver.

Afterwards, the performance of the coarsening algorithm will be investigated for all grid types in two and three dimensions. The miltigrid method will be applied for inviscid, laminar and turbulent flows.

References

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