Comparison of Grid Adaptation techniques for High Lift Flows Applications

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ABSTRACT

In recent years, numerical design techniques are being applied to configurations of increasing complexity. High lift configurations present a big challenge for design processes due to their associated physical and geometrical complexity. In today's standard CFD tools the accuracy of the solutions is highly dependent on the grid resolution. In addition to the grid generation best practices, adaptive grid methods are attractive to be introduced in numerical design chains because they offer the advantage of improving the solution accuracy with a low level of user intervention. Within the EU-funded research program DeSiReh (Design, Simulation and flight Reynolds number testing for advanced High-lift solutions) one activity is being devoted to investigate grid adaptation techniques aimed at obtaining suitable unstructured grids to improve the accuracy of CFD prediction within optimization processes. This paper describes the application of two grid adaptation approaches in the framework of high lift computations.

The first grid adaptation approach is based on the far-field drag breakdown method. This method makes it possible to decompose the aerodynamic drag according to its physical sources. An additional outcome of this method is the ability to detect areas of the mesh where spurious drag is created due to numerical sources. By using this ability, it is possible to formulate adaptation indicators that target regions of spurious drag creation. Two grid adaptation indicators are examined in this paper. The first one is a modification of the entropy drag indicator originally proposed in [1] for inviscid flows. The entropy drag indicator has been extended to viscous flows in high lift configurations. The second far-field drag indicator is based on the ONERA's one-vector formulation of drag breakdown [2]. The absolute value of the density of drag destruction/production has been selected and evaluated for adaptation indicator.

Both indicators have been implemented within an adaptive strategy which uses statistical parameters to mark the regions for adaptation. The far-field drag adaptation methodology has been tested on the 3D test case KH3Y (fuselage, wing, and full span slat and flap) wind tunnel model in landing conditions. Coarse and fine hybrid unstructured grids have been generated within DeSiReh in order to compare the effectiveness of the grid adaptive approach against the baseline computations. The computations and grid adaptations were performed with the DLR-TAU code. The results obtained on the tested configurations indicate that an improvement of the drag prediction can be obtained with this method with a moderate increase of nodes relative to the initial grid.

The second adaptive approach is based on the application of adjoint techniques for a posteriori error estimation and grid adaptation [3]. This technique is based on the estimation of the discretization error of a given output functional using a dual weighted residual representation of the error. The method was implemented previously into the TAU solver and tested for 2D and 3D inviscid flows [4]. In the present paper the method has been extended to viscous flows and applied to 2D high lift configurations. Some practical issues concerning the implementation and computational efficiency are also examined in the paper. The results obtained on the A310 geometry in landing configuration indicate that similar accuracy levels relative to a sequence of uniformly adapted grids can be achieved with 5-10 times fewer grid points. Figures 1 and 2 show an example of the adapted mesh and solution obtained with the adjoint-based approach.

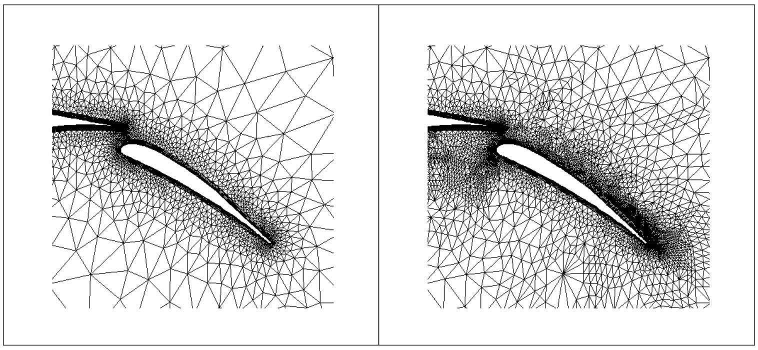

Figure 1: Initial and adjoint-based adapted grids for the A310 configuration

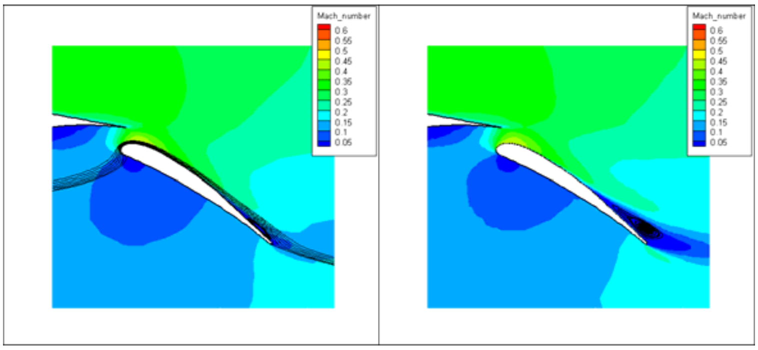

Figure 2: Initial and adjoint-based adapted flow solutions for the A310 configuration

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