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HIGH-ORDER MESH GENERATION FOR CFD WITH AERONAUTICAL APPLICATIONS

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In the recent years, high-order numerical methods have been shown to yield superior computational efficiency in problems with high resolution requirements, compared to standard second-order solvers based on Finite Volume technology. However, as the maturity of high-order schemes such as Discontinuous Galerkin methods is being brought to the level of practical application, many contributions show that their accuracy strongly depends on the accuracy of the geometrical discretization (see for instance [1]). It is thus necessary to develop the matching curvilinear mesh generation technology in order to fully benefit from the efficiency of high-order schemes. In this talk, we will present the methods that have been developed in the framework of the IDIHOM project for the generation of high-order unstructured meshes.

We adopt an indirect approach that consists in creating first a linear unstructured (or hybrid mesh), and then curving its boundaries to match the geometry. This often results in tangled elements, that can be identified by a change of sign in the Jacobian of the transformation between a curved element and its straight-sided counterpart. An additional step is thus necessary, in which invalid elements are untangled (see Fig. 1).

In CFD problems for aeronautical applications, most of the tangled elements are usually found in the boundary-layer part of the hybrid mesh. Such invalid elements can be untangled through a simple and inexpensive interpolation procedure that "propagates" the curvature in the direction normal to the boundary. However, this technique can generally not be applied to the whole mesh. The remaining invalid elements are thus fixed through a more robust and general method. It consists in solving a sequence of unconstrained optimization problems that progressively bring the Jacobian of each element within a user-defined range, through the use of moving log-barriers [2]. A key ingredient of the

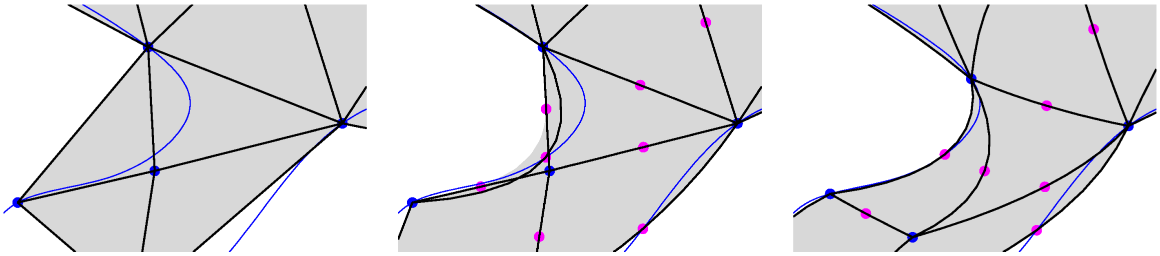

Figure 1: Straight sided mesh (left), primary curvilinear (quadratic) mesh with tangled elements (center), and untangled mesh (right).

method is the reliable estimation of the Jacobian bounds [3]. The procedure is applied to patches of elements surrounding an invalid element, instead of the whole mesh, for the sake of computational efficiency.

We apply these techniques to several high-order meshes built for aeronautical applications, such as the case shown in Fig. 2. We show that the combination of the fast interpolation and the more general optimization method makes it possible to generate valid high-order meshes for practical cases with affordable computational resources.

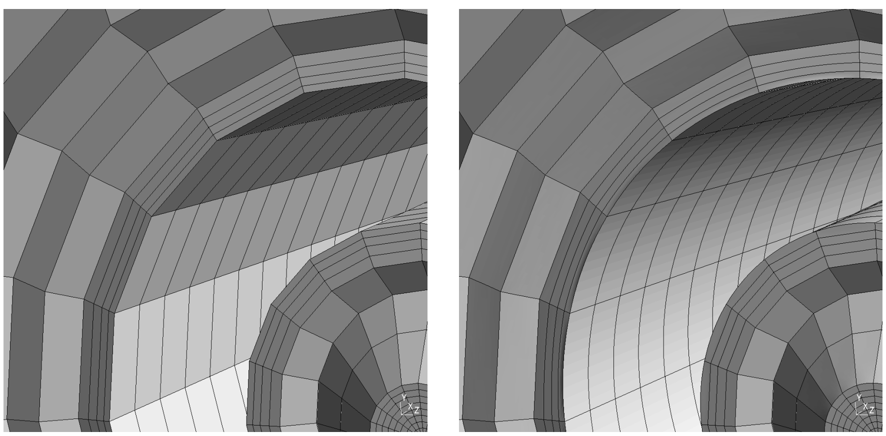

Figure 2: Detail of the external boundary layer part in the first-order (left) and untangled quadratic (right) meshes for the case of a nozzle.

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