3D HYBRID GRID GENERATION AND APPLICATION TO NAVIER-STOKES COMPUTATIONS

Aristotelis Athanasiadis, Greece
Supervisor & Promoter: Prof. H. Deconinck (ULB)

One of the biggest challenges in grid generation is the adequate resolution of thin diffusion layers close to boundaries. These layers are typical for applications like the simulation of high Reynolds number flows and the modeling of ion transport in electrochemical plating reactors, if one is interested in drag and mass transfer respectively.

The present work extends the previously acquired experience at the VKI from 2 to 3 dimensions. In the approach developed in the previous years, the thin diffusion layers are resolved by highly stretched semi-structured layers of quadrilaterals. In 3D this method creates layers of stretched prisms or hexahedra starting from a surface mesh. In a second step the rest of the computational domain is filled with unstructured isotropic elements (triangles in 2D, tetrahedra in 3D).

The model definition that has been adopted is the b-rep representation of the ISO10303 norm (also know as STEP). This format was designed for the exchange of data between different CAD systems and contains all the geometrical as well as the topological information necessary for hybrid grid generation. This reduces the time spent for grid generation in a typical industrial design cycle which includes CFD simulations, which is one of our goals in the ESPRIT project AMeGOS that is partially supporting this work.

Last year, work was focused on the volume grid generation part of the project. Using the previous experience, a new implementation was created with significant efficiency improvements. It currently allows to generate unstructured grids that are more that 3 times larger than what it is possible with the commercial tools available at VKI. Furthermore, the unstructured generation algorithm was extended with anisotropic remeshing capabilities based on a metric map which controls the tetrahedral element size, shape and orientation. This map can be defined analytically, or can be extracted from a previous solution through the Hessian matrix of one or more solution variables. In the semi-structured generation part, hybrid quadrilateral/triangular surfaces can now be used as a starting point without the need of splitting. Finally a novel method was developed which improves the semi-structured grid quality in convex and concave areas of the geometry. The method works by unfolding (for convex) or folding (for concave) the semi-structured generation front, thus creating a multiple or collapsing normal effect respectively. The main advantages of this approach are that the same algorithms and data-structures can be used, convex and concave cases are treated consistently and a conformal grid is always produced.

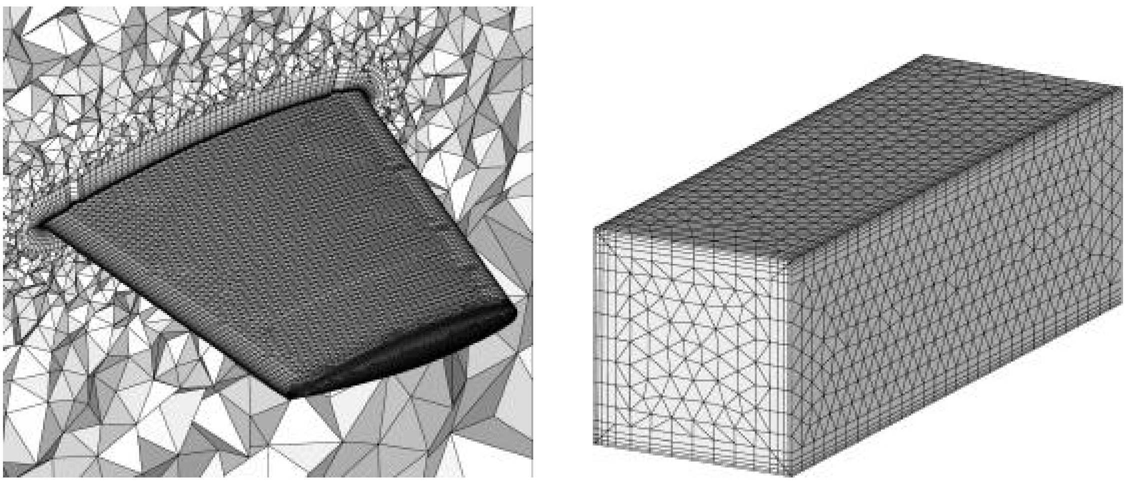

Figure 1: Left: Hybrid grid on the ONERA M6 wing with quadrilateral/triangular surface grid and front unfolding at the convex wing trailing edge. Right: Hybrid grid in a square channel with front folding in the concave corners.