CFD Meshing Strategies for Hypersonic Design Applications

Summer Internship Project for Priscilla Pak (G74)

Problem: CFD for hypersonics has traditionally emphasized high-order numerical methods and structured grids as the gold standard for accurate simulation, and in some corners of the community they are viewed as a prerequisite for generating plausible and meaningful results. However, these types of simulations have such high computational costs that they are impractical for use on the majority of applications relating to vehicle design and large-scale phenomenology; furthermore, there is reason to believe that the stringent requirements associated with small-scale phenomena like boundary layer instabilities and Kolmogorov-scale turbulence may not apply to a wide variety of practical flows (for example, resolving vehicle wakes or shock structures). The hypersonic aero-thermal team in Group 74 has had success using both unstructured grids and lower-order schemes for high-speed applications and would like to study the capabilities of these tools further.

Goal: Determine "best practices" for generating unstructured meshes for hypersonic CFD applications by using a sample geometry to complete a parametric study which determines the effects of the following parameters on the accuracy of computed flow quantities:

- Cell density
- Cell type (quadrilateral vs tetrahedral)
- Voxel vs traditional unstructured grid
- Grid alignment/shock fitting

The generated grids will be run at a range of flight conditions encapsulating different parts of the hypersonic regime to capture the effects of these grid changes on both equilibrium and nonequilibrium flow.

Deliverables: It is hoped that this project will result in a set of "best practices" describing the best approaches to meshing for hypersonic CFD applications using Group 74's tools. This could take the form of a set of slides or a more formal written report. If there is enough material generated during the project, it could perhaps be included as part of a conference paper or journal publication.

Tools/Resources: Grids can be generated in Pointwise; CFD calculations will probably be done primarily in Kestrel.