Gradients evaluation in mixed-element meshes

Cosimo Tarsia Morisco*, **Lucille-Marie Tenkès***, **Julien Vanharen*** **and Frédéric Alauzet***

* GAMMA Team, Inria Saclay Ile-de-France, 91126 Palaiseau, France
e-mail: cosimo.tarsia-morisco@inria.fr

ABSTRACT

In the context of fluid dynamics calculations, unstructured mesh adaptation has proven to reduce significantly the mesh size while keeping a high level of accuracy and automating the process of mesh generation [2, 3, 4, 5]. However some kinds of phenomena, such as boundary layers, are better captured by numerical schemes designed for structured meshes that are aligned with the boundary of the domain. In order to take advantage of unstructured mesh adaptation and meet some directional requirements, mixed-element meshes appear to be a good compromise.

In this talk, we describe how gradient discretization in such cases is clearly not trivial and three different formulations are required to maintain a second-order accuracy. Convective fluxes are discretized using an appropriate modified version of the Vertex Centered Mixed Element-Volume (V4) MUSCL scheme [1], enabling the treatment of quadrilateral and prismatic elements. Viscous fluxes are discretized using the APproximated Finite Element (APFE) method [6]. Nodal gradients in boundary and sources terms are discretized with a generalization of *Clement*'s L^2-operator which is crucial in case of highly anisotropic mixed-element meshes.

Some numerical results for 2D and 3D mixed-element meshes involving triangles, quadrilateral, tetrahedra and prisms will be shown. Some of these will be those obtained on best practice meshes of AIAA HLP.

REFERENCES

[1] Debiez, Christophe, and Alain Dervieux. "Mixed-element-volume MUSCL methods with weak viscosity for steady and unsteady flow calculations." Computers & fluids 29.1 (2000): 89-118.

[2] Alauzet, Frédéric, and Loïc Frazza. "Feature-based and goal-oriented anisotropic mesh adaptation for RANS applications in aeronautics and aerospace." Journal of Computational Physics 439 (2021): 110340.

[3] Alauzet, Frederic, et al. "4th AIAA CFD High Lift Prediction Workshop results using metric-based anisotropic mesh adaptation." AIAA AVIATION 2022 Forum. 2022.

[4] Alauzet, Frederic, et al. "Some progress on CFD high lift prediction using metric-based anisotropic mesh adaptation." AIAA SCITECH 2022 Forum. 2022.

[5] Alauzet, Frédéric, Loïc Frazza, and D. Papadogiannis. "Periodic adjoints and anisotropic mesh adaptation in rotating frame for high-fidelity RANS turbomachinery applications." Journal of Computational Physics 450 (2022): 110814.

[6] Puigt, Guillaume, Valerie Auffray, and J-D. Müller. "Discretisation of diffusive fluxes on hybrid grids." Journal of Computational Physics 229.5 (2010): 1425-1447.