Efficient Generation of High-Order Boundary Layer Meshes

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ABSTRACT

In recent years, the interest of the Computational Fluid Dynamics community for simulating high Reynolds-number flows by means of high-order numerical schemes has been growing. This type of flows features boundary layers, that typically require a high numerical resolution and a faithful representation of the geometry to be correctly computed.

It is now widely recognized that high-order schemes cannot deliver the proper accuracy in practical cases unless they are used in conjunction with high-order meshes that closely approximate curved wall boundaries. So far, research efforts have mostly been focused on producing valid and geometrically accurate meshes [1, 2]. With many widespread schemes, however, the high-order nature of the mesh affects not only the representation of the boundary, but also the approximation of the velocity profile in the boundary layer [3].

In this work, we tackle the problem of efficiently generating high-order meshes that improve the representation of curved boundaries without degrading the finite element approximation of velocity profiles in boundary layers. We first assess the adequacy of traditional boundary layer meshes made of geometrically-growing layers of cells in the context of high-order finite element approximations. We then introduce a method for curving such linear meshes in an analytical manner according to the wall boundaries. The technique is devised to be computationally efficient, while preserving the validity and the approximation properties of the mesh. We finally give practical examples hybrid high-order meshes generated with this method for high Reynolds number fluid dynamics applications.

REFERENCES

[1] Moxey, D., Green, M.D., Sherwin, S.J. and Peiró, J. An isoparametric approach to high-order curvilinear boundary-layer meshing. *Comput. Methods Appl. Mech. Engrg.*, Vol. **283**, pp. 636–650, (2015).

[2] Toulorge, T., Lambrechts, J., Remacle, J.-F. Optimizing the geometrical accuracy of curvilinear meshes. *J. Comput. Phys.*, Vol. **310**, pp. 361–380, (2016).

[3] Hindenlang, F.J., Gassner, G.J., Munz, C.-D. Improving the accuracy of discontinuous Galerkin schemes at boundary layers. *Int. J. Numer. Meth. Fluids*, Vol. **75**, pp. 385–402, (2014).