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# Error-driven high-order mesh *r*-adaptation

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We propose an approach to $r$-adaptation driven by *a posteriori* error indicators for application to high-order CFD simulations. Past work on moving meshes has focused on the concepts of equidistribution and alignment [1] focused primarily on linear meshes.

The developments hereby presented extend previous work of Marcon *et al.* [2] on high-order metric-based mesh $r$-adaptation in the open-source framework *NekMesh*. It is based on a variational approach which relies on the minimisation of an energy functional, function of the deformation of individual elements. $r$-adaptation is achieved by considering an isotropic scaling towards an ideal element size derived from *a posteriori* error indicators. This $r$-adaptive strategy is coupled with the high-order Discontinuous Galerkin (DG) solver *Aghora*. A discretisation error estimator based on the Variational Multiscale Simulation approach is used to guide the adaptive algorithm. This error indicator has been shown to provide similar performances for $p$-adaptive DG methods to more complex residual-error based indicators while producing smoother error fields [3].

This work focuses on the optimal conversion from the error indicator to the target element size. To demonstrate the computational gain provided by this technique, we consider three test cases: an inviscid subsonic flow over a Gaussian bump and a flow past a NACA0012 aerofoil in laminar subsonic and inviscid transonic regimes. Thanks to $r$-adaptation, we are able to achieve a twofold objective, distribute local error and reduce global error, by moving degrees of freedom to regions that require higher spatial resolution. Although isotropic, this approach exhibits anisotropic behaviour due to geometrical constraints and patterns in the error distribution. Finally, we observe that different conversion approaches produce similar results with respect to global and local error but influence convergence rates of both the variational optimiser and the adaptive algorithm to an optimal mesh.

## REFERENCES

[1] W. Huang and R.D. Russell. *Adaptive Moving Mesh Methods*, volume 174 of *Applied Mathematical Sciences*. Springer New York, New York, NY, 2011.

[2] J. Marcon *et al.* A variational approach to high-order r-adaptation. In *IMR26*, 2017.

[3] F. Naddei *et al.* A comparison of refinement indicators for p-adaptive DG methods for the Euler and Navier-Stokes equations. In *2018 AIAA SciTech Forum*, 2018.