Anisotropic Error Estimates for Adapted Dynamic Meshes

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ABSTRACT

The simulation of real-life problems, with complex moving geometries evolving in unsteady flows in three dimensions, still remains a challenge. To reduce the CPU time of these simulations while preserving their accuracy, anisotropic metric-based mesh adaptation, which has already proved its efficiency for steady problems, appears as a salutary perspective. However, its extension to the unsteady moving mesh case is far from straightforward.

The problematic is that the multiscale mesh adaptation described in [1] only controls spatial errors. But, in the context of time-dependent problems, temporal errors must be controlled as well. In this study, we do not account for time discretization errors but we propose a space-time analysis of the spatial error in unsteady simulations. From this analysis, we design a global iterative fixed-point adaptation algorithm. In this algorithm, the time interval of the simulation is divided in sub-intervals, keep the same adapted mesh for each time sub-interval. These meshes are generated using hessian metrics averaged on the sub-intervals.

This analysis is first performed for unsteady simulations with fixed geometries, then the case of moving meshes is considered. In that case, moving boundaries induce a displacement of the whole mesh to keep a good mesh quality (see [2]). The error estimate is modified to take into account the movement of the mesh. Given a sensor function at time t^{k+1} and displacement field d between t^k and t^{k+1}, we express an ALE metric field at time t^k, from which a mesh at time t^k is generated, which, once moved with displacement d, will be adapted to the sensor at time t^{k+1}. The case of linear [3] and quadratic displacements will be considered. The resulting ALE metric allows us to modify the fixed-point unsteady adaption algorithm to take into account the mesh movement, and to couple it with a moving mesh algorithm [2] and an ALE flow solver.

Finally, several 3D examples of moving-mesh unsteady adaptation will be given and analyzed.

REFERENCES

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