Adjoint based mesh adaptation techniques for simulation of turbulent flow

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ABSTRACT

The fundamental model of fluid flow is the Navier-Stokes (NS) equations, and the use of computational methods to simulate fluid flow is referred to as computational fluid dynamics (CFD). Sometimes CFD amounts to computing numerical approximations to the NS equations, but for turbulent flow direct numerical simulation (DNS) of the NS equations is too expensive to be practical. Also, individual particle trajectories in turbulent are chaotic, hence, impossible to predict with any computational method. In the automotive and aerospace industries, RANS (Reynolds averaged NS equations) is still the standard form of CFD. In RANS only averaged solutions of the NS equations are computed, which is a much less expensive method than DNS, but at the cost of the introduction of new model parameters that need to be determined.

Mesh adaptation in CFD offers excellent opportunities to improve the efficiency of simulations, since in many situations the need for high mesh resolution is concentrated to only some small regions of the computational domain. These regions are typically very hard to predict before the simulation, but with a posteriori error estimation the mesh adaption can be focused to these regions as part of the computation itself. Adjoint based mesh adaptation techniques rely on the solution of an associated adjoint equation, which provides sensitivity information which can be used in a posteriori error estimation to identify what parts of the domain that contribute the most to the error in the output of interest in a simulation.

In this paper we address the challenges of adjoint based mesh adaptation in the setting of industrial CFD, characterized by complex geometry and high Reynolds numbers. We use a space-time finite element discretization of the NS equations, and we focus on the challenges of massively parallel algorithms [2] and the mathematical formulation of the NS equations [1].

REFERENCES

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