Adaptive Finite Element Simulation of Multi-Physics Turbulent Flow with Applications in Aerodynamics

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ABSTRACT

The error magnitude and the order of accuracy of a new unsteady Variational MultiScale (VMS) solver are examined. Indeed, while vast majority of industrial simulations today are restricted to only computing a statistical average of the flow field, we propose in this work the simulation of unsteady turbulent flows using finite element methods with residual based stabilization to solve the Navier-Stokes equations. The basic idea is to consider that the unknowns can be split in two components, coarse and fine [1], corresponding to different scales or levels of resolution. Compared to early Large Eddy Simulation approaches (LES) where small scales are explicitly solved introducing a Smagorinsky-type dissipative term, the proposed VMS acts here as an implicit Large Eddy Simulation (ILES) technique by solving first the fine scales, then by tracking them in time and finally by replacing their effect into the large scales taking into account their nonlinearity. As a result, an important fraction of the degrees of freedom are used for the small resolved scales whereas consistency is retained in the large resolved scales only. We show that the new solver gains also efficiency and robustness by incorporating dynamic anisotropic mesh adaptation [2] and increases accuracy by including a new a posteriori error estimator that deals with boundary layers and flow detachments. Therefore, several test cases and confrontation with literature are proposed. The massively parallel simulations and comparisons with experimental results of flows past complex 3D industrial geometries such as a drone will be presented.

REFERENCES

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