Compact High-Order Accurate Scheme for Unstructured Grids and Turbulent Incompressible Multi-Fluid Flows

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ABSTRACT

In the last decades, there has been a considerable attention towards high-order accurate numerical schemes for Computational Fluid Dynamics (CFD) applications within the research community [1]. The reason is that the current commercial and industrial CFD codes based on Finite Volume Method (FVM), which are at best second-order accurate, are not efficient enough for some complex problems such as vortex-dominated flows. An example of such is the viscous flow simulation around a maneuvering ship. This particular example is a highly turbulent flow with Reynolds number ranging from 10^6 to 10^9. Thus, turbulent models such as Reynolds-Averaged Navier-Stokes (RANS), Large Eddy Simulation (LES) or hybrid RANS/LES have to be investigated and validated.

When it comes to research in high-order schemes, the family of Discontinuous Galerkin (DG) Finite Element Method (FEM) is very popular. It has some interesting properties such as being locally conservative, stable for convection-dominated problems, highly parallelizable. In addition, DG methods are able to handle complex geometries and require simple treatment of boundary conditions while maintaining the high accuracy all over the computational domain [2]. This makes DG methods very attractive for CFD applications.

Moreover, the aforementioned example of a maneuvering ship involves multi-fluid (air-water) flow all within the limit of incompressibility hypothesis. The simulation of this free-surface incompressible flow requires an interface-capturing technique to numerically resolve the position of the air-water-ship interfaces. An example of such interface-capturing techniques is the Level-Set method. Some work has been done to incorporate the Level-Set method into a DG framework, as for instance the work presented in [3].

REFERENCES

[1] Wang, Zhijian J., et al. "High-order CFD methods: current status and perspective." *International Journal for Numerical Methods in Fluids* 72.8 (2013): 811-845.

[2] Cockburn, Bernardo, George E. Karniadakis, and Chi-Wang Shu. "The development of discontinuous Galerkin methods." *Discontinuous Galerkin Methods*. Springer, Berlin, Heidelberg, 2000. 3-50.

[3] Utz, Thomas. *Level set methods for high-order unfitted discontinuous Galerkin schemes*. Diss. Technische Universität, 2018.