6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Grid refinement using spectral error indicators with application to airfoil DNS

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Key Words: Structured grids, error indicator, direct numerical simulation, airfoil

High-order direct numerical simulations require smooth grids with continuous metric terms across block boundaries. In this contribution we present an approach to generate structured grids around airfoils with a blunt trailing edge that are continuous up to the second order of derivatives. Due to the large size of the grids and the complexity of modern wing geometries, the grid generation could not be accomplished with available commercial software effectively, and required new techniques that allow more precise control over the distribution of grid points, the spacing and stretching. A new grid generation tool, based on polynomial definition of grid spacing along block edges, enables target-oriented refinement of identified under-resolved regions in the computational domain. Dassault Aviation's V2C airfoil is used as a case study, involving 3D as well as 2D simulations that solve the Navier-Stokes equations directly. An iterative process for grid validation and refinement is proposed. The grid consists of up to five billion grid points to resolve the transonic flow at a Mach number and Reynolds number of M=0.7 and Re=500,000, respectively. The evaluation of grid quality is an important aspect in order to use computational resources efficiently. A spectral error indicator analyses the Fourier spectrum of cube-shaped subdomains to identify critical regions of the grid, where refinement is needed. If the spectral energy of small-scale fluctuations in the flowfield does not decay at a certain rate, they are assumed to be caused by grid-to-grid point oscillations [1]. This methodology aims to reduce the computational effort when designing and validating large complex grids and has been successfully applied to current DNS studies. A recommended guideline of the full grid generation process including the refinement strategy will be presented, based on a best-practice procedure that was developed during the course of a project investigating transonic buffet phenomena over laminar-flow wing sections.

REFERENCES

[1] Jacobs, C. T., Zauner, M., De Tullio, N., Jammy, S. P., Lusher, D. J., and Sandham, N. D., An error indicator for finite difference methods using spectral techniques with application to aerofoil simulation. In *Computers and Fluids*, 2018.