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RANS Simulations of Flows around Complex Geometries using Locally Refined Cartesian Grids.

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ABSTRACT

The present paper describes the principal aspects of a CIRA in-house developed simulation system based on Cartesian grids and an immersed boundary technique [1]. The system is composed of an user-friendly automatic grid generator coupled with a vectorized flow solver for EULER/RANS equations. The system is thought as a fast pre-design method for aeronautical/industrial flows around complex 3D configurations. A fully unstructured data management is adopted. A local grid refinement without restrictions on the number of refinement levels can be performed in an anisotropic way. The equations are solved by a finite volume method with a Jameson-like scheme.

The immersed boundary methodology is applied by a discrete forcing approach. The body force that mimics the effect of the body on the flow is obtained by the imposition of a direct boundary condition. The face-center quantities can be reconstructed by using different interpolation schemes involving surrounding known values (cell centers, wall points) and the IB local unit normal vector. The wall distance is computed by solving a Poisson equation for a scalar quantity whose gradient is somehow connected to it [2].

Turbulence is introduced to deal with medium/high Reynolds number flows.

The closure of RANS equations is obtained by using the k-g turbulence model starting from the standard Wilcox k-ω by the change of variables $g = \frac{1}{\sqrt{\beta^* \omega}}$ as suggested in [3][4]. For medium/high Reynolds number flows it is difficult to fully resolve the boundary layer, therefore a wall modelling is introduced to enforce the velocity “law of the wall”, and drive correctly the turbulent quantities at the immersed boundary surfaces[5].

The robustness of the methodology and the accuracy of the approach are discussed. The method is applying to classical test-cases for which experimental data are available in literature. The flow around the NACA0012 and RAE 2822 airfoils are considered as 2D applications. A 3D simulation around the Onera M6 wing is presented. The results will be discussed by comparing with experimental and body-fitted numerical solutions.

REFERENCES

[1] Capizzano F., "A Compressible Flow Simulation System Based on Cartesian Grids with Anisotropic Local Grid Refinement", 45th AIAA Aerospace Sciences Meeting, Reno Nevada, 2007, AIAA Paper 2007–1450.

[2] Tucker P. G., Rumsey C. L., Spalart P. R., Bartels R. E. and Biedron R. T., "Computations of Wall Distances Based on Differential Equations", 34th AIAA Fluid Dynamics Conference and Exhibit, 2004, Portland, Oregon, AIAA Paper 2004–2232.

[3] Kalitzin G., A. R. B. Gould, J. J. Benton, "Application of two-equation turbulence models in aircraft design", AIAA 34th Aerospace Sciences Meeting and Exhibit, Reno, NV, 1996, AIAA paper 96-0327.

[4] Kalitzin G., Iaccarino G.,, "Toward Immersed Boundary Simulation of high Reynolds Number Flows", Center for Turbulence Research, Annual Research Briefs 2003, Stanford University, USA, pp. 369-378

[5] Catalano P. , "Transonic Flow Simulations using Wall Functions", 2nd European Conference for Aero-Space Sciences (EUCASS), June 2007, Bruxelles.