NUMERICAL ALGORITHMS FOR THE COMPUTATION OF UNSTEADY COMPRESSIBLE FLOW OVER MOVING GEOMETRIES - APPLICATION TO FLUID-STRUCTURE INTERACTION

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A class of residual distribution schemes has been experiencing a bustling development over more than two decades. The development was recently advanced by the success of construction the unsteady schemes, which has been shown superior in the comparison with more usual methods for solving hyperbolic problems. Clearly, it is appealing to take an advantage of its accuracy and apply the schemes for the fluid-structure interaction problems.

First, the RD scheme had to be extended to the Arbitrary Lagrangian-Eulerian (ALE) formulation of the governing equations. Space-time schemes were already avaliable [1]. This formulation can be proven second order accurate in C^8 norm and stable in L^8 norm, however it suffers from the poor iterative convergence for higher time-steps, which prevents its successful application for the fluid/structure interaction problems. A new scheme called Bx, with improved properties was developed [2]. This scheme is based on a simple blend between the LDA scheme with consistent mass matrix and the N scheme with lumped mass matrix. An ALE method was developed using the consistent finite element approach of the problem. Resulting scheme has been successfully tested on a number of problems including 2D and 3D gas compression in the piston and oscillating airfoil NACA0012.

A finite element method is nowadays standard for solution of complex problems of elastic structures. We have implemented higher order anisotropic finite element method with large structural displacements and modal analysis capabilities. The method is coupled with the flow solver via simple sub-iteration approach.

The method was validated on a 2D panel flutter problem and AGARD 445.6 wing. The results are compared with state of the art finite volume method.

[1] Dobeš, Deconinck: A Second Order Space-Time Residual Distribution Method for Solving Compressible Flow on Moving Meshes. AIAA Paper 2005-0493. 2005

[2] Dobeš, Deconinck: Second Order Blended Multidimensional Residual Distribution Scheme for Steady and Unsteady Computations. Journal of Computational and Applied Mathematics (JCAM). Accepted for publication.

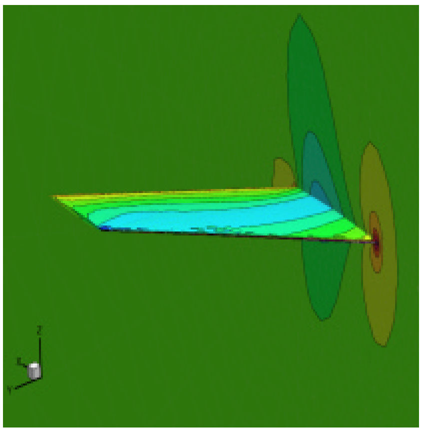

Figure 1: AGARD 445.6 wing. LDA scheme. Isolines of the pressure.

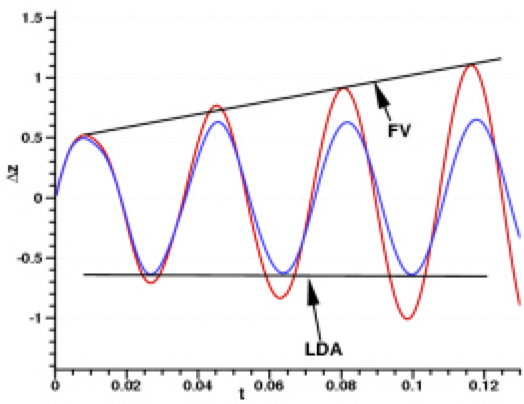

Figure 2 : AGARD 445.6 wing. Neutral regime. Deflection vs. time.