8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

A WAY OF HIGHER ACCURACY AEROACOUCTICS SIMULATIONS ON UNSTRUCTURED GRIDS

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Key Words: *Computational Aeroacoustics, Higher-Accuracy Algorithms, Unstructured Grids*

ABSTRACT

A high accuracy of numerical algorithms on unstructured meshes remains a crucial point in solving aeroacoustics problems for engineering applications. A quality of aeroacoustics simulations is principally determined by an accuracy of hyperbolic problem solver in use.

The paper considers a higher-order vertex-centered multi-parameter scheme [1], [2] built on the base of first-order upwind type scheme [3] within the finite-volume approach for unstructured triangular and tetrahedral meshes. A specificity of that FV scheme is that it becomes a finite difference scheme of high accuracy (up to the 6^{th} order depending on the choice of parameters) when applying to a "Cartesian" regions of mesh. "Cartesian" regions mean the mesh parts consisting of rectangles or cubes divided on rectangular triangles or tetrahedrons. The viscous terms are approximated with the second order of accuracy using piece-wise linear interpolation.

The above scheme properties apply special requirements on the mesh. To reach a higher accuracy, the mesh has to contain as more extended "Cartesian" parts as possible. In doing so, an important mesh parameter is the ratio between the sizes of rectangular and non-rectangular elements. It should be noted that depending on the scheme-accuracy parameters the ration significantly exceeding one provides a better efficiency of the solver.

In the one-dimensional case, an accuracy improvement of the basic upwind scheme is implemented in the way of two-stage method of modified equation [4]. Following that technique, a piece-wise constant representation of fluxes within a cell is replaced by modified piece-wise fluxes with a slope determining by a combination of first and third difference derivatives. In the multi-dimensional case, the analogical slopes are a weighted sum of gradients on the corresponding triangles (tetrahedrons) and Hermite gradients representing the first and third difference derivatives.

The paper is devoted to a study of the scheme properties depending on a type of mesh and cells. The results of model simulations in 1D and 2D cases are presented.

A scheme of computational experiments on the accuracy estimation is demonstrated in Figure 1. A plane channel with an acoustic wave entering from the left is considered. The problem is governed by the linearized Euler equations. Numerical results are compared with the exact solution along a fixed check cut. Different types of meshes and cells are considered and their influence on the numerical result accuracy is analyzed.

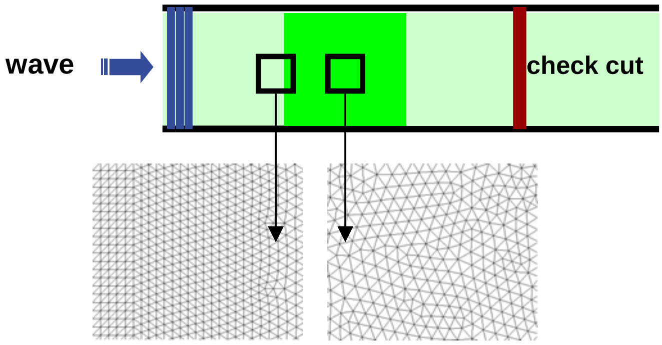

Figure 1: Scheme of 2D computational experiment on the solver accuracy estimation.

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