UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

A Z-ORDERING CARTESIAN GRID METHOD AND ITS APPLICATION IN FLOW SIMULATION

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A new method of automatic and robust Cartesian mesh generation method for two-dimensional and three-dimensional flow simulation problems is developed and introduced in this thesis. The new algorithm adopts an idea of zigzag mapping from computer graphics for terrain generation. Three achievements have been presented in this thesis. A coherent Z-ordering is applied into the grids' topological structure. By deploying this ordering to quadtree/octree, a robust grid navigation algorithm is developed. The algorithm simplifies the grid's navigation procedure, which is usually the most time consuming part in both the grid generation and flow simulation. A binary coding system is developed to mark the grids, instead of using a decimal coding system. Finally, a second-order finite volume scheme is developed based on the analysis of various current schemes. Both two-dimensional and three-dimensional schemes are presented in this thesis. Thus, a unique fast Cartesian grid generation method is provided.

A finite volume Navier-Stokes flow solver is discussed and applied to refined Cartesian grids presented in this thesis. Both two-dimensional and three-dimensional flow cases are chosen in this thesis for numerical simulation at various Reynolds numbers. The validity and performance of this Cartesian grid are tested in these flow simulations and results prove that the Cartesian grids presented in this thesis have very good performance at low Reynolds numbers flows.