Abstract

The present work aims at the development of High Resolution Flow Solver on Unstructured Meshes (HIFUN-3D), a general purpose flow solver for Euler equations of Gas Dynamics The code is based on cell centre finite volume formulation and uses unstructured data The use of unstructured data makes the code HIFUN-3D capable of handling grids with hexahedral, tetrahedral, prismatic, pyramidal or any combination of these basic elements The computation of geometric quantities required by the code HIFUN-3D, like cell volume and centroid, surface normals, is cast in a general way, independent of cell topology The code makes use of least squares based linear reconstruction procedure for enhancing the solution accuracy and employs Venkatakrishnan limiter for ensuring solution monotonicity The code HIFUN-3D is equipped with a variety of numerical schemes for interfacial flux computation and a variety of boundary conditions In addition, there is a provision for the user to add a new scheme and/or boundary condition Unstructured data based codes are enormously memory intensive and are required to be equipped with certain memory saving techniques The code HIFUN-3D makes use of a novel memory saving device called Migratory Memory Algorithm (MMA) The use of MMA can still be relevant in the present days of memory boom, in the sense that the problem size a given machine can handle can be substantially bigger than the case not employing such a device The code HIFUN-3D makes use of implicit relaxation procedures like point Jacobi (PJ), symmetric Gauss Seidel (SGS) and lower-upper symmetric Gauss Seidel (LU-SGS), in matrix free formulation, for accelerating convergence in steady state computations At this point, it should be remarked that the matrix free formulation of PJ procedure is cast as a face based algorithm in the code HIFUN-3D We bring out the effect of simple Cuthill Mckee reordering on the performance of these iterative procedures in the context of cell centre finite volume framework We also show that the use of MMA improves the performance of aforesaid iterative procedures without resorting to any reordering procedure due to betterment in

the cache utilization, in spite of the fact that MMA involves additional computations The code HIFUN–3D is equipped with embedded grid refinement allowing for hanging nodes In addition to grid enrichment, the code also has a provision for coarsening the regions of the grid that are overrefined The algorithm of grid adaptation is novel, in the sense that it does not make use of tree data which is most common for such type of algorithms Instead, the adaptation algorithm makes use of unstructured data similar to the one used in the flow solver Further, the adaptation algorithm is cast as a face based procedure, akin to flux computation The use of embedded refinement with hanging nodes leads to the formation of grids with arbitrary polyhedral volumes The code is capable of handling such grids also The code HIFUN–3D is developed to address two classes of problems The first class involves the problems encountered in routine design cycle, like computing flow past a wing, for which the code HIFUN–3D can be used in serial mode on relatively small machines like personal computers, workstations etc The second class involves the problems requiring massive computational resources, like computation of flow past entire aircraft configuration, for which the code HIFUN–3D can be used in parallel mode on supercomputers or distributed memory parallel processing machines The parallelization of code HIFUN–3D is achieved using standard mode blocking and non–blocking features of Message Passing Interface (MPI)

Due to the aforementioned features, it can be said that the code HIFUN–3D is general in terms of

1 handling geometric complexities frequently arising in industrial computations,

2 handling complicated flow physics within the regime of validity of its mathematical model, i e Euler equations and

3 utility, since the code can not only be used for performing industrial computations in a product design cycle but also as a research tool