ON LOCALLY REFINED MESH PROCESSING FOR PARALLEL CFD

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Key words: *dichotomic meshes, mesh partitioning, space filling curves, CFD*

An accurate numerical prediction of many CFD problems, especially computational aeroacoustics (CAA) problems, requires a careful resolution of different space scales. One of the ways to simulate those problems is a usage of meshes locally refined in the regions of interest. In addition, such meshes refined in a dichotomic way appear efficient in the case of some special high accuracy schemes. Among them there is the DRP (Dispersion-Relation-Preserving) scheme [1] for computational aeroacoustics problems.

The first part of paper is devoted to the DRP scheme adaptation to the locally refined meshes and considers, in particular, different types of interpolation preserving the scheme properties. The main difficulty concludes in a 7-points stencil of the scheme.

A processing of locally refined meshes for parallel computations needed for CFD applications is not evident. A widely used way of mesh partitioning provided by the METIS library [2] may be not optimal from the standpoint of minimizing the data exchange.

There are a number of approaches used for an optimal storing and partitioning of meshes of special structures. In most cases they are based on mapping the multidimensional data to one-dimensional array using specific space-filling curves [3], [4].

In the second part the paper considers an algorithm of mesh partitioning based on the Hilbert's space filling curve [5]. That curve is applicable when the locally refined mesh under consideration represents a quadtree or octree in 2D and 3D case correspondingly. In the present work the Hilbert's curve is used not only for a mesh nodes enumerating and the following mesh partitioning, but also for producing a complete and compact description of the mesh.

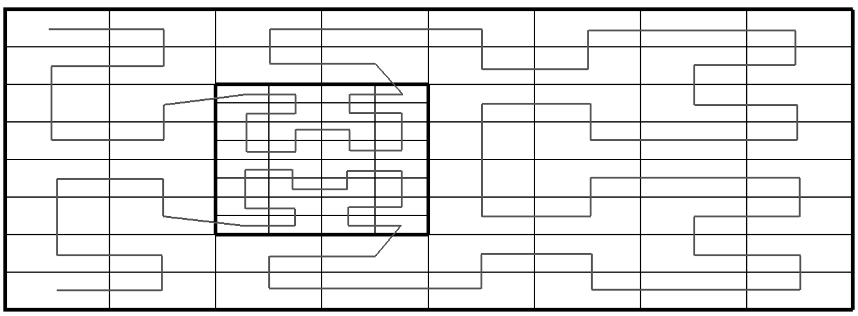

Fig. 1: An example of the Hilbert's curve-based enumeration of quadtree mesh nodes

That approach gives an extremely small mesh representation with the two vital features:

- it has a good locality preserving behavior (much better than the other analogical curves);

- it allows of an easy adaptive mesh refinement by element merging/splitting with minimal changes in the Hilbert's curve-based numeration of nodes.

The proposed algorithm is very useful for simulating unsteady CFD and CAA problems on large adaptive locally refined meshes of quad/octree type since, as it is mentioned above, the Hilbert curve structure allows both to describe the mesh in the most compact and handy way, and to use the same structure for an easy dynamic mesh refinement.

The paper shows the results of comparison of the proposed mesh partitioning algorithm with the METIS partitioning. A comparative analysis of the different partitioning types is made also in dependence of the computational method in use. The scheme under such an analysis is the DRP scheme. Benchmark CAA problems on the Gaussian pulse evolution are considered.

The paper gives examples of using the described algorithm for locally refined meshes in cases of computational domains with a great difference of scales.

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