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Hierarchical Meshing and Its Applications to Adaptive Large-Scale FEM

***Kohei Murotani[1] and Genki Yagawa[2]**

[1] Toyo University
2-36-5, Hakusan, Bunkyo-ku, Tokyo,
112-0001, Japan
muro@ccmr.toyo.ac.jp

[2] Toyo University
2-36-5, Hakusan, Bunkyo-ku, Tokyo,
112-0001, Japan
yagawa@eng.toyo.ac.jp

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ABSTRACT

In this paper, we discuss a fast and efficient algorithm using out-of-core memory for an ultra large meshing and adaptive analysis. A mesh for the FEM is usually generated by a procedure that nodes are allocated and then connected. Triangulation and tetrahedration of Delaunay tessellation are popular in this context. However, using these methods, the whole domain is forced to be re-meshed even if it is unnecessary. To avoid this problem, we study a hierarchical meshing to perform adaptive analyses of solid and fluid mechanics effectively, demonstrating that the total computer time is considerably decreased.

First, a whole region is divided into very fine triangular elements. Then, two neighbouring elements with a shared edge are collapsed and two shared nodes of the edge are reduced into a new node using an operation called the edge collapse. If the edge collapse is done, the sizes of neighbouring elements are increased. As this edge collapse is repeated, the original fine mesh transfers to a coarser one. At the same time, a set of nodes is represented as a binary-tree data structure, and an adaptive mesh is automatically generated by going up and down in this binary-tree. It is noted that the hierarchical mesh be generated before the analysis, which usually costs considerable amount of CPU time and memory size. But, once generated, the hierarchical mesh can be used repeatedly for every re-meshing. Additionally, as the mesh is changed at a necessary part only, the CPU time is negligible, which is an advantage of the binary-tree approach.

However, a critical issue of the hierarchical mesh is that the adaptive mesh depends on the element size of the initially generated fine mesh. If the initial mesh is divided into much smaller elements, not only CPU time but the memory space are considerable for generation of the hierarchical mesh. Due to this reason, we may often encounter accuracy problem to solve singularity problems and so on. To resolve this issue, we consider to use hard disk as storage space for the initial large mesh and to generate a hierarchical mesh with parallel computing. Since a hierarchical mesh is generated only

by a local transformation, performance of parallel computing is very high. Using this strategy, we apply this method to high speed adaptive analysis of ultra large scale FEM.

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