MASSIVELY PARALLEL COMPUTING OF FRACTURE MECHANICS BY FREE MESH METHOD

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Recent improvement of computer technology has had profound influences on computational science and engineering. Under this environment, the inquired needs in future as well as traditional concepts of design, manufacturing and simulation are being changed rapidly by incorporating advances of related technologies. The purpose of this paper is to present a promising methodology for massively parallel computing of fracture mechanics by 'free mesh method'[1-2]; algorithm of node-by-node free mesh method, details of fracture mechanics analysis solver, availability of the methodology and ongoing activities to enhance the capabilities.

The node-by-node methodology proposed in this research starts from a local mesh generation based on new constrained Delaunay triangulation algorithm that was derived to overcome the weak points of previous algorithms. It uses geometric operations to search appropriate satellite nodes within a minimized local area and utilizes multi-level buckets. A massively parallel computing is facilitated through these features and, thereby, robust local elements can be generated while maintaining sufficiently complex geometries and/or boundary conditions. A fracture mechanics analysis solver has been developing in connection with this mesh generation algorithm. The basic scheme of the currently available solver is an explicit method and Newmark's β method is being considered also. It adopts a crack tip moving technique to simulate propagation behaviors instead of conventional node release technique. During the process, a crack path at each time step is determined through the combination of stress intensity factors obtained from virtual crack extension method. In order to verify the validity and applicability of the proposed methodology, several quasi-static fracture mechanics analyses have been carried out for various specimens and crack geometries under different loading types. The analyses were implemented on distributed-memory parallel machines and reasonable results were achieved successfully.

This research has been performing as part of frontier simulation software development project in which the final goal is to construct a next generation structural analysis system[3]. Since the current prototypes of massively parallel mesh generator and quasi-static fracture analysis solver showed a good applicability, several activities are being carried out continuously. The ongoing key activities corresponding to fracture mechanics are incorporation of virtual parallelization technique into the mesh generator, development of dynamic fracture mechanics analysis solver, industrial application and extension of the developed and developing methodologies.

References

[1] G. Yagawa and T. Yamada, "Free Mesh Method: A New Meshless Finite Element Method," *Computational Mechanics*, v. 18, p. 383-386, 1996.
[2] G. Yagawa and T. Furukawa, "Recent Developments of Free Mesh Method", *Int. J. Numer. Meth. Engng.*, v.47, p.1419-1443, 2000.
[3] G. Yagawa et al., "NEXST: NEXt STructural System," *Implementation Plan for FSIS Project*, 2002.