Development and Practical Application of General Purpose Parallel Structural Analysis System

Hiroshi Akiba, Allied Engineering Corporation
Shinobu Yoshimura, University of Tokyo
Hirohisa Noguchi, Keio University
Tomonobu Ohyama, Allied Engineering Corporation
Takashi Kawakami, Toyama Prefectuctural University

1. Introduction

HPC (High Performance Computing) is growing rapidly. However, it has not been applied to practical CAE analyses. The performance of the CAE analyses cannot be considered satisfactory in the field of product design where the product development cycle is shortening. The parallel structural analysis code we have developed, which we named ADVC, runs on massively parallel systems, as well as standard cluster systems and workstations; and it has the capability of large scale analysis. A number of manufacturers have been introducing the code ADVC.

2. The Parallel Analysis System ADVC

ADVC is a commercial structural analysis code, which has been developed based on the frame work of the ADVENTURE system. The latter was developed by the "Research for the Future" program of the JSPS (Japan Society for Promotion Science). ADVC has a solver named CGCG method based on a domain decomposition algorithm on the iterative substructuring method.

A tremendous amount of research has been done on the domain decomposition method for the implicit structural analysis by the iterative substructuring method. The most primitive idea is that first the inner areas of the subdomains are solved, and then the solution is superimposed into the equation of the boundaries between subdomains which we call inner boundaries, and CG method is applied to this equation.

The Neumann method takes each subdomain as a substructure. On almost all substructures the Neumann condition alone is assumed, therefore indefinite rigid motions of the subdomains appear and the stiffness matrices of these subdomains are not necessarily regular. We take the summation of these generalized inverse matrices as a precondition matrix of the CG method. But an unfavorable condition caused by the indefinite rigid motions of the subdomains aggravates the convergence of the CG method.

Mandel ([1]) and Farhat ([2]) developed innovative different methods BDD and FETI, respectively, both of which eliminate the indefinite rigid motions caused by Neumann method by taking the global rigid body motion of the subdomains into account. Those two methods gave practical performance to the iterative substructuring method.

Both BDD and FETI solve each subdomain as a substructure. However, from our study, there is no need to solve each subdomain in view of the precondition of the CG method; in addition, solving substructures comes with a large calculation cost. The authors developed a method in which the global rigid body motion is applied only to the precondition of the parallelized global CG method on the global space. We named it CGCG method ([3]). The convergence and the efficiency of the memory usage drastically improved.

3. Analysis Example of Electronic Device

The authors conducted a drop impact analysis of a mobile phone using ADVC in cooperation with IBM Watson Research Center, using IBM Blue Gene/L 8 racks, 8192 nodes. The work was selected as the Gordon Bell Prize finalist at Supercomputing 2006 ([4]). The main point of the analysis is that the CAD file was imported almost directly, the model size was as large as 305 million of degrees of freedom, and the dynamic analysis was done by the implicit method. The simulation time is about 2.5 milliseconds; calculation time is about 28 hours. An example of the analysis results is shown in Fig.1. From this analysis, we obtained evaluations such as the stress propagation and other characteristics that were impossible to estimate by experiment.

4. ADVC in the Industries

Since its commercialization in 2001, ADVC has been introduced by automakers, auto parts manufacturers, electronic companies, precision equipment manufacturers, heavy industry companies, energy plant makers, iron and steel makers and a variety of other major manufacturer and research institutes. These users are motivated by both the need to perform large scale analysis which was impossible for so long and the need for high performance in calculation speed.

5. Conclusions

A brief description of ADVC's technical background and its influence on industry has been given. The need for large scale analysis will continue to grow and will be more important than ever. The authors feel very fortunate to have been able to develop a technology that will certainly be an integral part of the manufacturing process for years to come.

References

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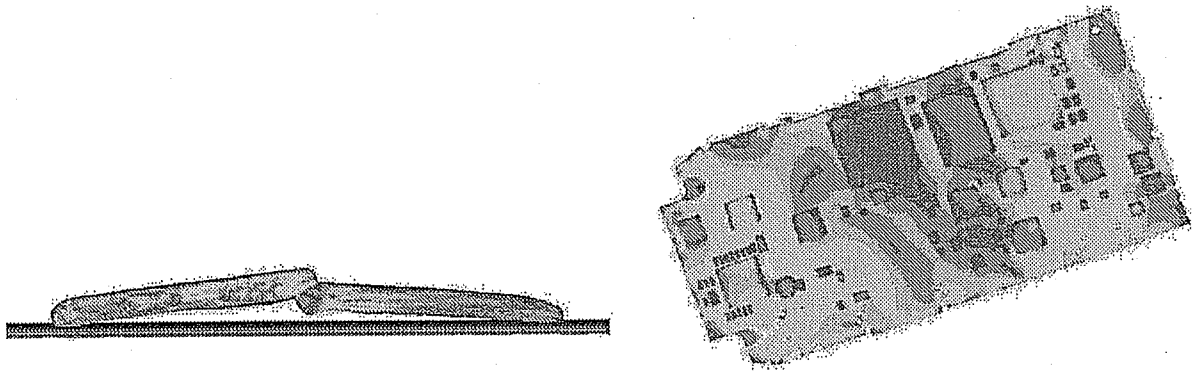

Fig.1 Example of Analysis Results of Mobile Phone
(After about 1 ms of crash; the color contour is the equivalent stress distribution;
the right hand side is the printed circuit board in the lower board)