Performance evaluation of data compression methods in linear static and dynamic finite element analysis

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Abstract

The size of numerical simulations such as finite element parallel analyses is constantly increasing and data sets produced by scientific programs and scanning devices are growing in size at an exponential rate. Storing such large quantities of data in standard uncompressed formats results in large files, and these files requires huge storage space and are slow to process and difficult or even impossible to transmit.

Strategies to combat this problem include data compression and quantity reduction of output data. By employing data compression technique, more compact data representations are produced and then less disk space for storage and less bandwidth are required. Among many of compression schemes for floating-point data compression, compression schemes with high compression rata and high accuracy are preferable. Here, we adopt an efficient data compression technique Jointed Hierarchical Precision Compression Number-Data Format (JHPCN-DF) [1] and implement it in a parallel finite element program ADVENTURE_Solid [2] in which hierarchical domain decomposition method (HDDM) [3] is used for structural analysis.

However, regarding methods to reduce required quantity of data for exchange or post calculations have not been studied. In this study, we propose a new method of data reduction for parallel finite element analysis using domain decomposition method (DDM), which is called DDM compression.

Compression rate and compression speed are evaluated and the effect on accuracy of reconstructed data by applying JHPCN-DF to static analysis and dynamic analysis is investigated. We found that JHPCN-DF has remarkable capability of data compression with high compression rate and high compression speed. In the case of static analysis, fast convergence is observed when reconstructed displacement data encoded by JHPCN-DF is used as initial value for solving the finite element equilibrium equation. In the case of dynamic analysis, required level of accuracy is achieved when JHPCN-DF is employed. We also found that DDM compression can dramatically reduce the sizes of output files, suggesting a direction for future data compression.

Our new data compression methods could be applied to variable areas of large scale simulations for achieving lower computation cost and high computation efficiency. Furthermore, these methods can alleviate problems caused by data explosion and will be relevant for the development of next-generation computation.

Keywords: Data compression, JHPCN-DF, domain decomposition method, DDM compression, parallel computation.

References

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