IMPROVING THE COMPUTATIONAL PERFORMANCE OF SOLVERS FOR GROUND MOTION SIMULATION AND STRUCTURE RESPONSE ANALYSIS

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RESEARCH REPORT

The research work conducted under the guidance of Prof. Tsuyoshi Ichimura and Assoc. Prof. Kohei Fujita of the Research Center for Computational Earth Science aimed on improving the computational performance of developed solvers for use in high fidelity ground motion simulation and structure response analysis. The specific works included (1) implementing a matrix storage format to efficiently perform matrix operations for 3D problems, (2) implementing GPU computing in the Conjugate Gradient (CG) solver, and (3) testing the improved solver for the target computational cost. The improvement in the solvers were tailored to the available GPU resources in the Philippines. With continuous development, physics-based solvers for earthquake engineering applications will soon be ported and optimized in the said computing resources.

Below are the outputs of the specific works*:

1. Block Compressed Row Storage (Block CRS) was implemented to replace the standard CRS of the developed solvers. This implementation reduced the computation time of matrix-vector product operation by 40% compared to the standard CRS.

2. A directive-based parallel programming model, OpenACC, was implemented in the CG solver that uses the Block CRS. For a preliminary test on a problem with 324,747 unknowns and using one GPU device, the computation time of CG iterations was reduced by 31% compared to the serial version. For an element-by-element matrix vector product operation with 1.2 Billion unknowns, the implementation of OpenACC reduced the computation time by 48%.

3. In testing the 3D FEM solver implemented with hybrid MPI-OpenACC for a 81.92-second, 265,200 unknowns - earthquake simulation, a 49% reduction in computation time has been achieved compared to the flat MPI version.

*Note: The values reported are results of basic implementation of OpenACC, i.e. no optimization has yet been introduced.

In addition, a collaborative research study is being undertaken that aims to improve a developed 3D displacement-based FE solver in terms of source modeling and implementation of absorbing boundary condition.

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