Accelerating Peridynamics Program Using GPU with CUDA and OpenACC

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Abstract

In order to model some materials that may naturally form discontinuities such as cracks as a result of deformation, the peridynamics theory is introduced by Silling (2000). In this theory, the formulation employs integral equations instead of partial differential equations and it is assumed that particles in a continuum body interact with each other at a distance. However, because it is a particle based method, the simulation of 3-D model requires a large number of particles and time steps. This leads to huge runtime requirements. Hence, to find ways to accelerate the peridynamics program becomes important to the research.

In this paper, we used two kinds of parallel computing methods to accelerate the peridynamics problems: CUDA (Compute Unified Device Architecture) and OpenACC. CUDA is a parallel language extension and OpenACC is a compiler directive. A bond-based peridynamics model of crack propagation was developed and tested using the two parallel computing methods. The results show that both methods can reach the speedups from 12 to 100 compared to the corresponding sequential implementation of peridynamics code. We also compared the differences between the two methods in speed-up ratio, time-cost of the code modification, multi-platform portability and utilization of GPU. Finally we will provide some suggestions on how to choose these two parallel computing methods.

Keywords: Peridynamics, Parallel Computing, GPU, CUDA, OpenACC.

References

Silling, S. A. (2000) Reformulation of elasticity theory for discontinuities and long-range forces, *Journal of the Mechanics and Physics of Solids* **48**(1): 175-209.