CUDA Homework Assignment 3

Hao-Tse , Hsiao

B12902100

Abstract. In Homework Assignment 3, we are required to solve the Poisson equation on a 3D lattice with boundary conditions. A unit point charge is placed at the center, and the resulting potential is analyzed as a function of radial distance. GPU acceleration is used to improve computational efficiency.

1 Task Description

We first initialize the potential at all grid points to zero, and set the central point charge to 1. We then apply Jacobi iteration using GPU acceleration to update the potential values over the lattice. After running the Jacobi process for `max_iter` steps, we output the results and use `plot.py` to visualize the potential as a function of distance.

2 Task Result

After performing `max_iter` times of Jacobi iterations , we got the result of potential versus distance (using log-log coordinate)

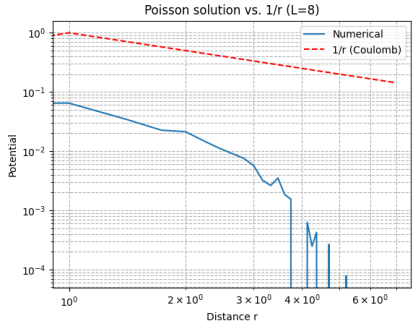
As shown in Fig. 1, the potential exhibits a similar trend to Coulomb's law at short distances. As L increases, the numerical results become smoother and closer to the theoretical $1/r$ behavior, especially for $L = 64$.

3 Discussion

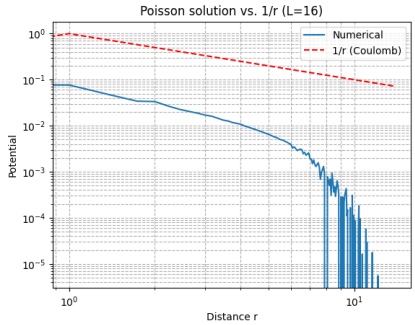
In this experiment, we observe that as $L \gg 1$, the numerical potential approaches Coulomb's law. However, boundary effects cause fluctuations in regions near the box edges. Increasing L smooths out the potential curve, improving agreement with the $1/r$ law. This demonstrates the importance of domain size in approximating continuous-space solutions in discrete lattices.

4 Reference

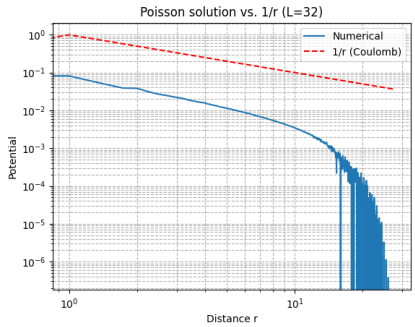
1. Introduction to CUDA Parallel Programming, National Taiwan University (2025). Homework Assignment 3.



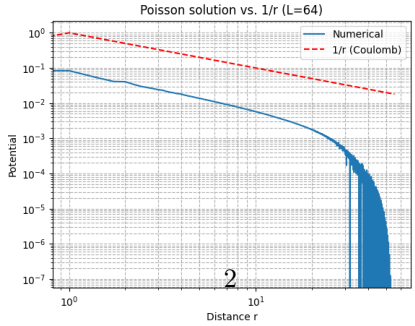
(a) $L = 8$



(b) $L = 16$



(c) $L = 32$



(d) $L = 64$

Fig. 1. Potential $\phi(r)$ vs. distance r from the point charge, computed on $L \times L \times L$ grids. As L increases, the numerical solution more closely approximates the analytical $1/r$ behavior.