Parallel Algorithms for Kernel Density Estimation

Namo Wichitrnithed[a], Rylan Spence[a]

[a] *Oden Institute for Computational Engineering and Sciences, University of Texas at Austin, Austin, 78712, TX, USA*

Abstract

Keywords: Kernel Density Estimation, Parallel computing, Cuda

1. Introduction

- **Project Motivation**
- **Brief literary review KDE (See References Below)**
- **Brief literary review Parallized KDE (See References Below)**

2. Multi-Core Programming Models

- **MPI**

  Basic Review of MPI Architecture

- **GPU**

  Basic Review of GPU Architecture

3. Serial vs.Vectorized vs. Multi-Core Kernel Density Estimation

- **Serial Algorithm Pseudo Code**
- **SIMD Algorithm Pseudo Code**
- **MPI Algorithm Pseudo Code**

Email addresses: `namo@utexas.edu` (Namo Wichitrnithed), `rylan.spence@utexas.edu` (Rylan Spence)

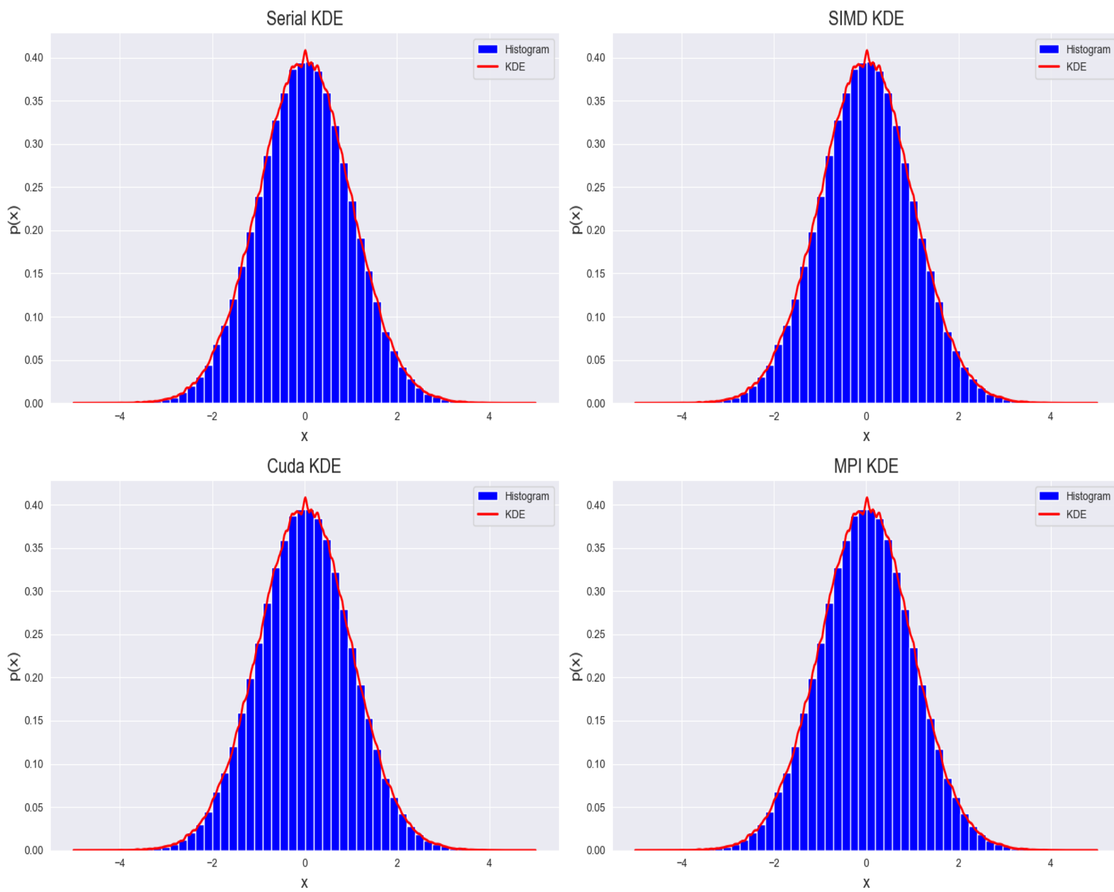

Figure 1: Kernel Density Estimates for all four proposed algorithms

- **Cuda Algorithm Pseudo Code**

-

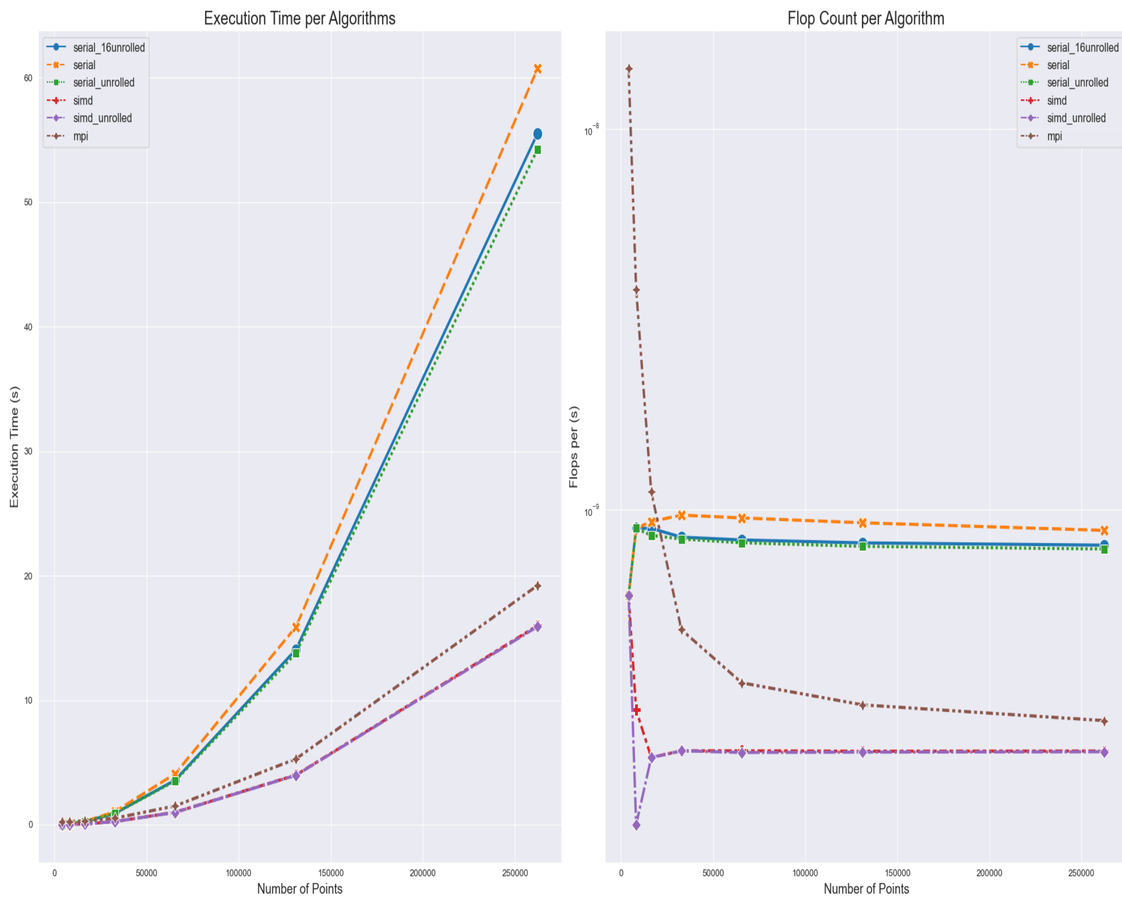

Figure 2: Execution times (in secs) of a kernel estimation as a function of the grid points.

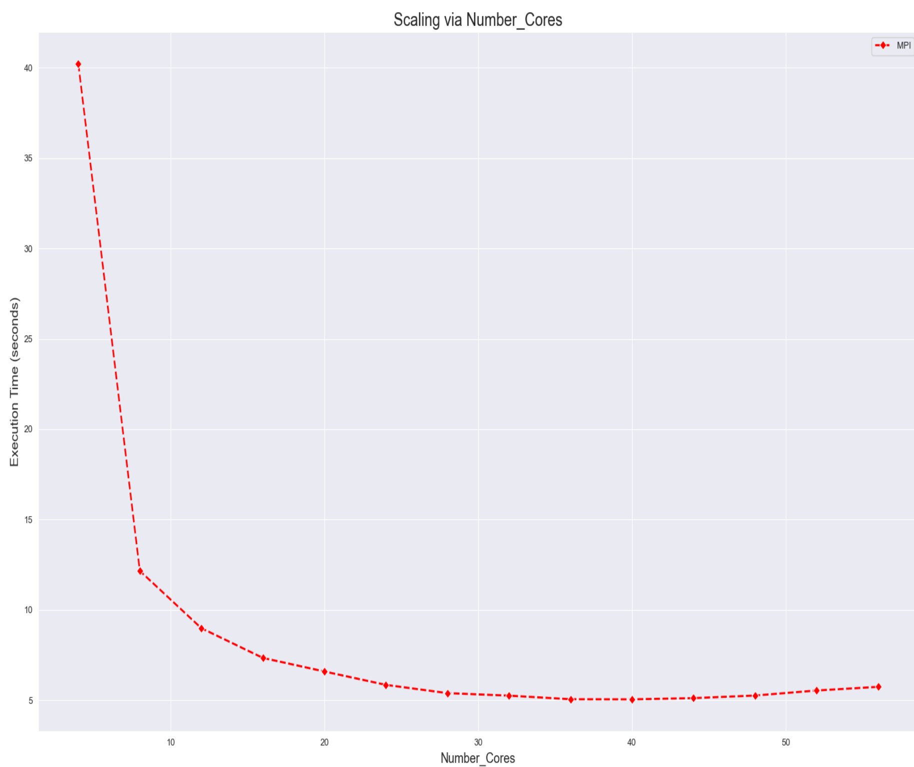

Figure 3: Execution times (in secs) of a kernel estimation as a function of the number of cores.

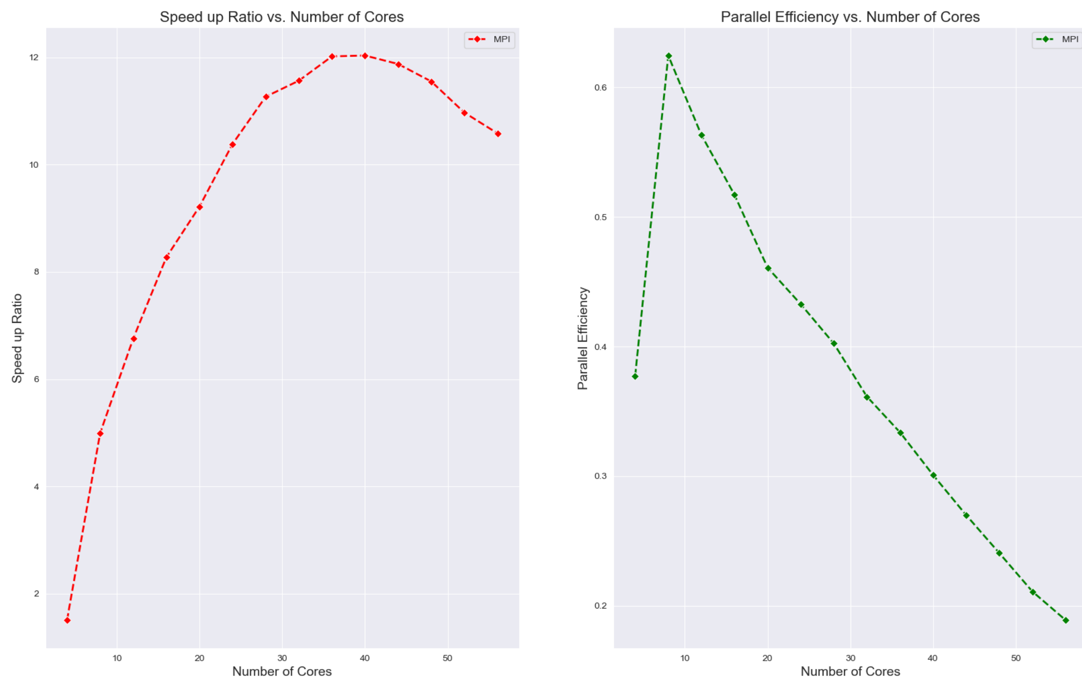

Figure 4: Performance of the MPI-parallel algorithm for KDE on the test data set (n = ?, m = ?): (a) speed up ratio and (b) parallel efficiency - defined as speedup ratio divided by number of CPU cores.

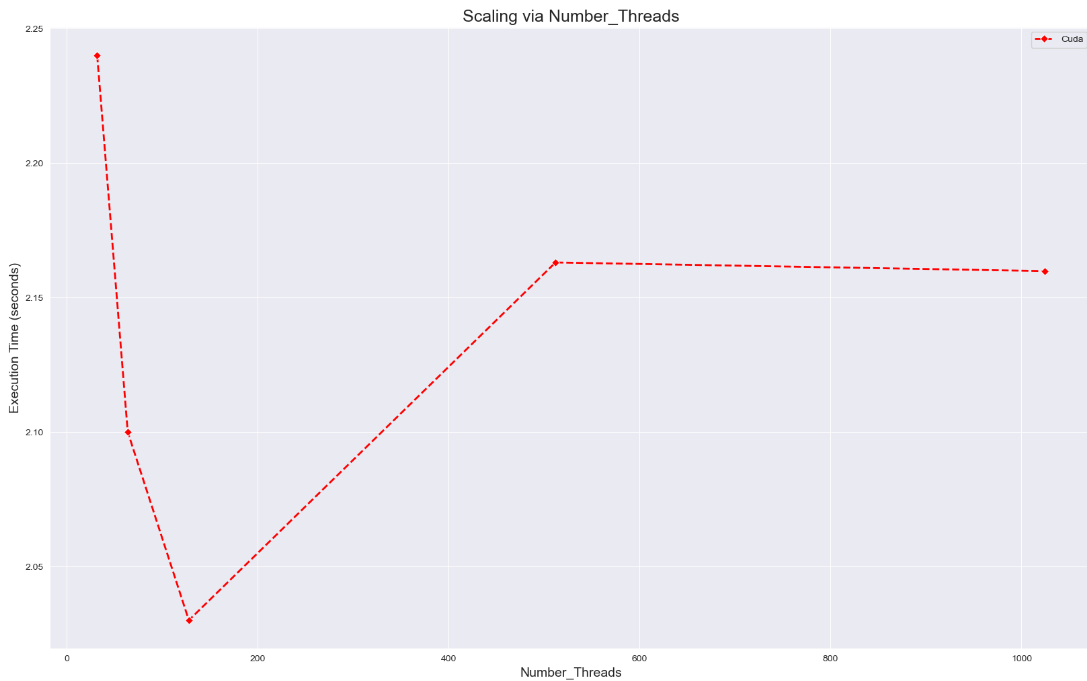

Figure 5: Scaling of the CUDA-parallel algorithm for KDE

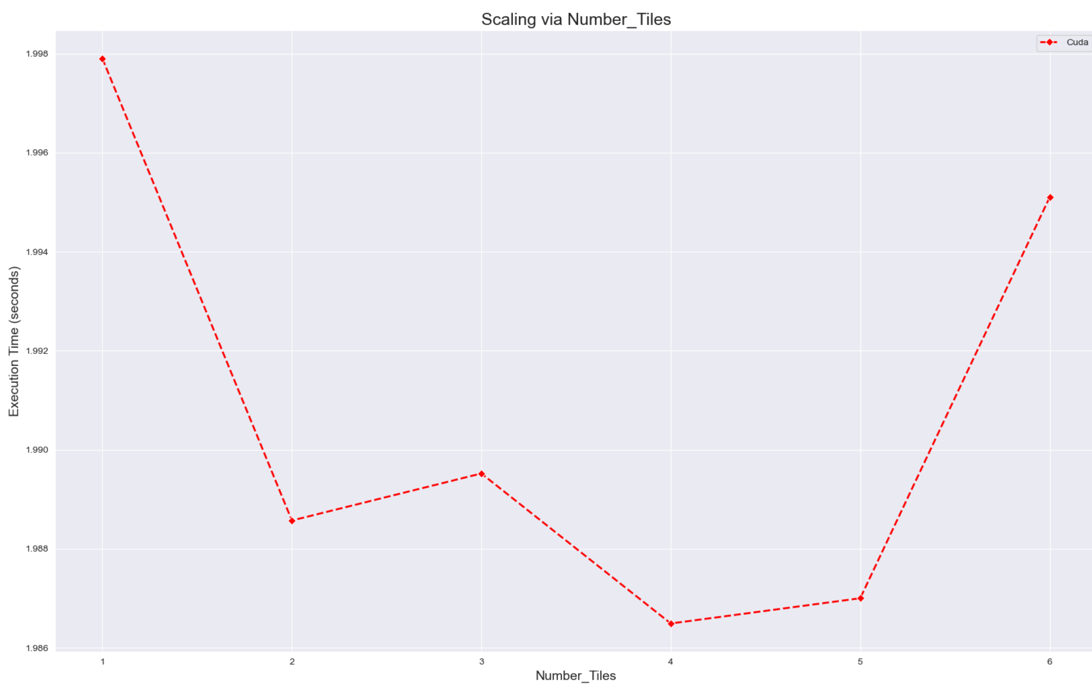

Figure 6: Scaling of the CUDA-parallel algorithm for KDE

Kernel Density Algorithm	*Serial*	*SIMD*	*MPI*	*Cuda*
Lines of code	12	17	10	12

Table 1: Lines of code in Programming Models

4. Results

4.1. Quantititative Comparison

4.2. Qualitative Comparison

5. Conclusions

References

[1] Kernel density estimation, Wikipedia.

[2] P. D. Michailidis, K. G. Margaritis, Parallel Computing of Kernel Density Estimation with Different Multi-core Programming Models, in: 2013 21st Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, 2013, pp. 77–85. `doi:10.1109/PDP.2013.20`.

[3] G. Zhang, A.-X. Zhu, Q. Huang, A GPU-accelerated adaptive kernel density estimation approach for efficient point pattern analysis on spatial big data, International Journal of Geographical Information Science 31 (10) (2017) 2068–2097. `doi:10.1080/13658816.2017.1324975`.