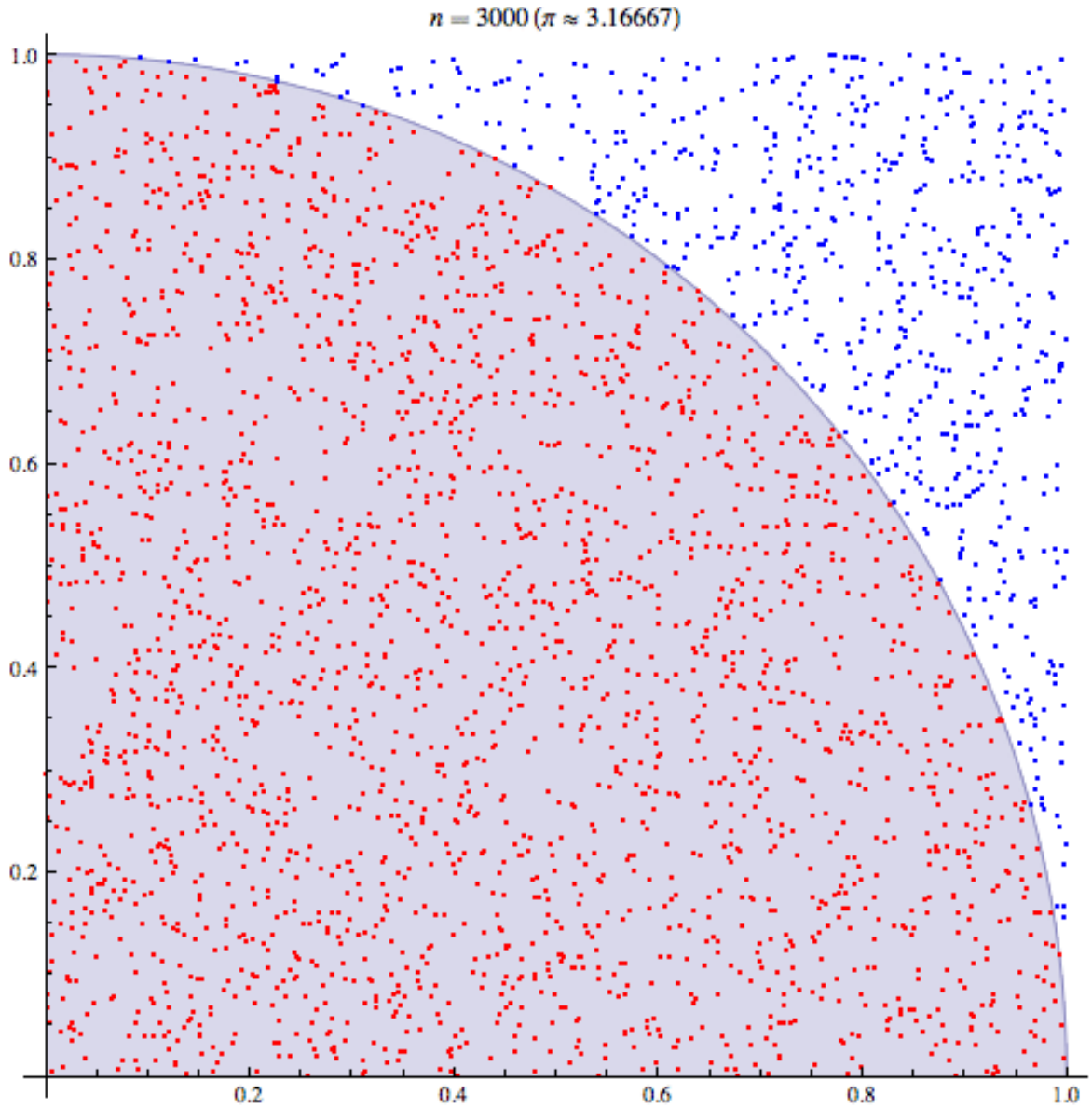
CS 595 Project Proposal: Quasi-Monte Carlo Integration using Lattice Cubature on GPU

Michael Bonilla

October 4, 2018

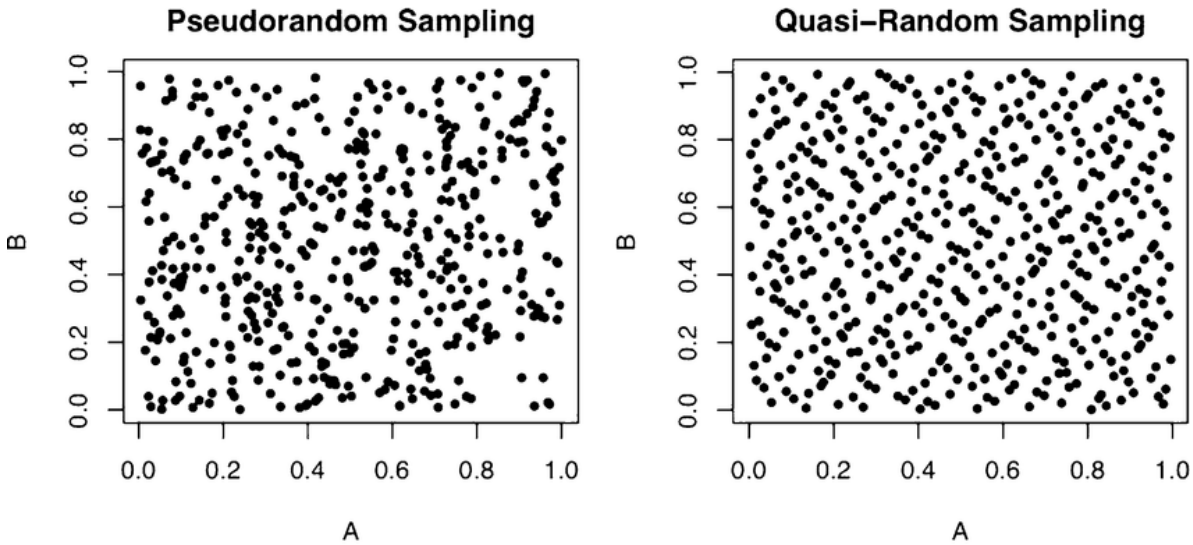
Introduction

- Monte Carlo to used for numerical integration of high dimensional problems.
- Traditional Monte Carlo uses pseudo random numbers (*rand*,*randn*).
- Branch of Monte Carlo is Quasi Monte Carlo that differs in how we chose our random inputs.
- Guaranteed Automatic Integration Library (GAIL)


$n = 3000\ (\pi \approx 3.16667)$
1.0
0.8
0.6
0.4
0.2
0.2
0.4
0.6
0.8
1.0

Introduction

- Monte Carlo to used for numerical integration of high dimensional problems.
- Traditional Monte Carlo uses pseudo random numbers (*rand*,*randn*).
- Branch of Monte Carlo is Quasi Monte Carlo that differs in how we chose our random inputs.
- Guaranteed Automatic Integration Library (GAIL)

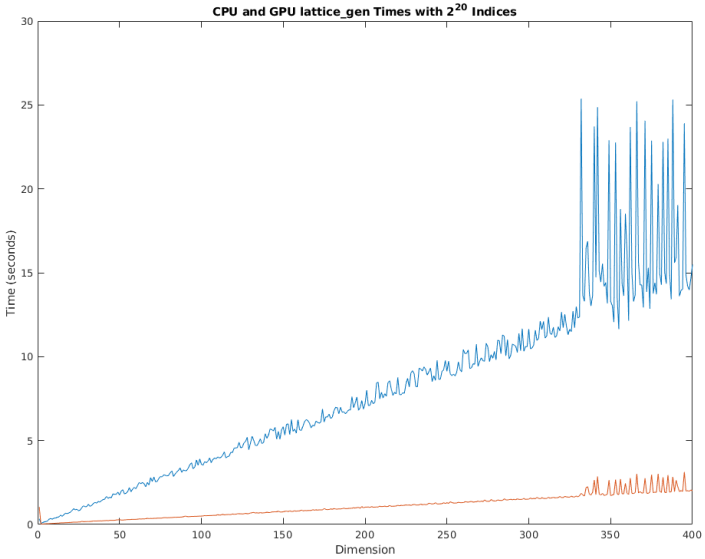

Pseudorandom Sampling
B
A
0.0
0.2
0.4
0.6
0.8
1.0
Quasi−Random Sampling
B
A
0.0
0.2
0.4
0.6
0.8
1.0

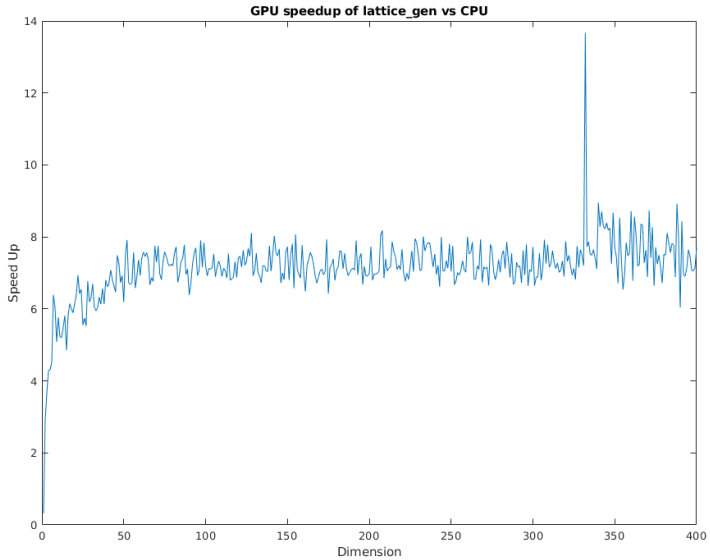
Introduction

- Monte Carlo to used for numerical integration of high dimensional problems.
- Traditional Monte Carlo uses pseudo random numbers (*rand*,*randn*).
- Branch of Monte Carlo is Quasi Monte Carlo that differs in how we chose our random inputs.
- Guaranteed Automatic Integration Library (GAIL)

Current Status

- GAIL is written in Matlab and has no GPU capabilities.
- Will be working on *cubLattice_g* and trying to speed it up.
- Currently sped up the generation of the lattices 6-8 times faster.


CPU and GPU lattice_gen Times with 2^{20} Indices
Time (seconds)
Dimension
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350
400


GPU speedup of lattice_gen vs CPU
Speed Up
Dimension
0
2
4
6
8
10
12
14
0
50
100
150
200
250
300
350
400

Proposed Work

- Work on *cubLattice_g* in three stages:
  1. Generation of lattices in parallel.
  2. FFT of points required for algorithm.
  3. Maintain the theme of automatic integration.
- Implement restrictions based on hardware.
- testing on suitable problems of large dimension.

Expectations and Further Work

- Implement a GPU version of *cubLattice_g*.
- Uphold automatic integration attributes.
- Benchmarking of performance vs CPU
- More robust control of GPU in Matlab

References

Sou-Cheng T. Choi, Yuhan Ding, Fred J. Hickernell, Lan Jiang, Lluis Antoni Jimenez Rugama, Da Li, Jagadeeswaran Rathinavel, Xin Tong, Kan Zhang, Yizhi Zhang, and Xuan Zhou.
Gail: Guaranteed automatic integration library (version 2.2).
Availablefromhttp://gailgithub.github.io/GAIL_Dev/, 2017.

Lluis Antoni Jimenez Rugama and Fred J. Hickernell.
"adaptive multidimensional integration based on rank-1 lattices,".
In R. Cools and eds. D. Nuyens, editors, *Monte Carlo and Quasi-Monte Carlo Methods: MCQMC*, volume 163, pages 407–422, Leuven, Belgium, April 2016. Springer Proceedings in Mathematics and Statistics.