Computation of Pi using CUDA

Dan Padgett
University at Buffalo

University at Buffalo The State University of New York

cse@buffalo

Background

- Want to find a way of utilizing CUDA to help improve times for computing digits of pi
- First attempt used numerical integration
  - Proved to be unhelpful
  - Rate of Convergence

Obstacles

- Original series converged too slowly
- Only double precision supported under CUDA 1.3 compute capability

Overcoming our Obstacles

- Found new series with fast convergence

$$\pi = \sum_{i=0}^{\infty} \left(\frac{1}{16^i}\right)\left(\frac{4}{8i+1} - \frac{2}{8i+4} - \frac{1}{8i+5} - \frac{1}{8i+6}\right)$$

University at Buffalo The State University of New York

cse@buffalo

Next Steps of Action

- Implemented new series
  - Sum converged to full precision in 8 iterations
  - Looked for higher precision library
    - Why has no one written one for CUDA?
    - We will soon find out...

Implementing Higher Precision

- Started with sequential C
- Modeled after IEEE 754 floating point specs
- Left precision as #define variable
- Was able to compute precisions up to 2600 integers per number on a worker node

University at Buffalo The State University of New York

cse@buffalo

Dan Padgett

12/17/2009

Stop... CUDA Time!

- Compiled vanilla C source in nvcc CUDA compiler
- Several issues
  - Incompatible low-level memory hacks
  - CUDA functions using structs are inlined
  - Limited CUDA memory, registers

CUDA Difficulties

- Replaced memory hacks with new memory hacks (maximum memset, extracting bits)
- Other issues not satisfyingly resolvable
  - Inlining → 10 minute compile time
  - Executable size neared 1MB
  - Limited shared memory → limited precision

Other Difficulties

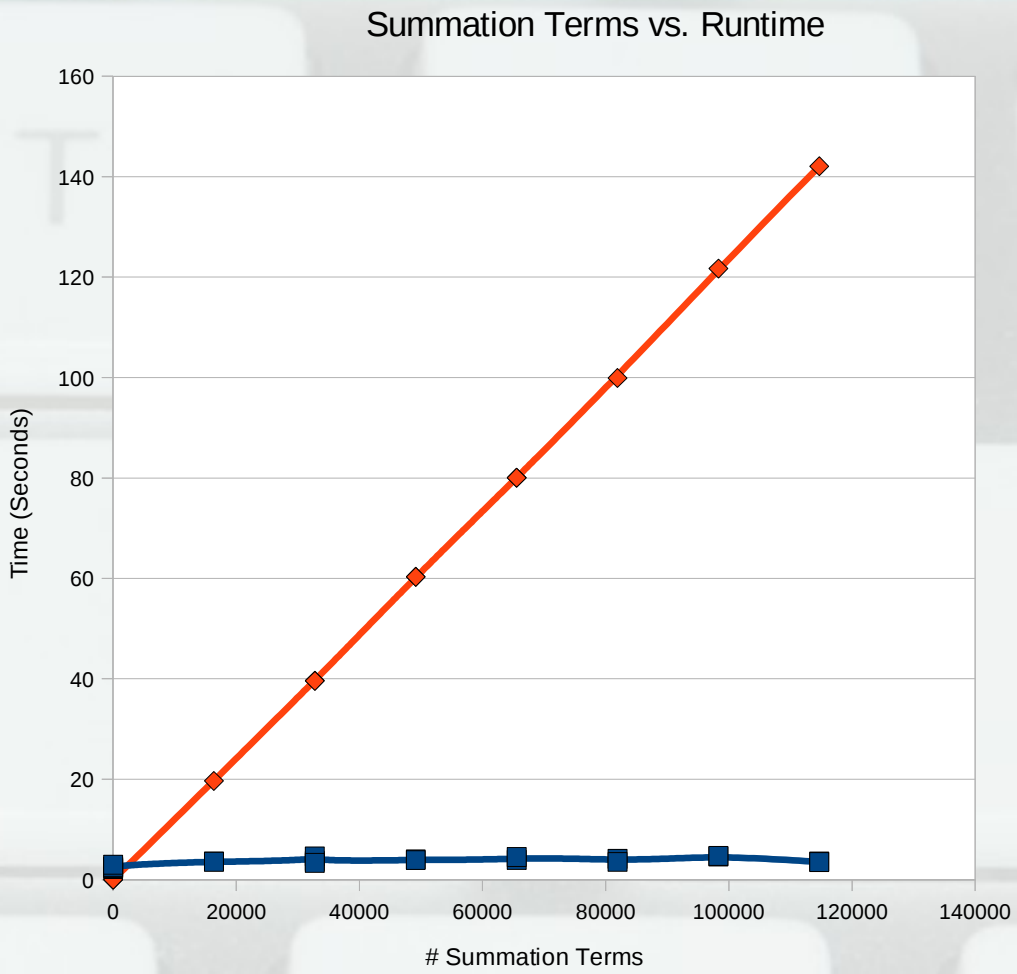
- Using higher precisions caused the compiler to simply crash
- Found precision = 12 uses maximum number of CUDA registers
- Nowhere near the capability of the sequential code

Results Cont.

- After the usual 6-8 second CUDA initialization time, code ran far faster than sequential equivalent (up to number parallel processors)
- Asymptotic behavior was as desired, even though the approximation wasn't as good as desired.

University at Buffalo The State University of New York

cse@buffalo



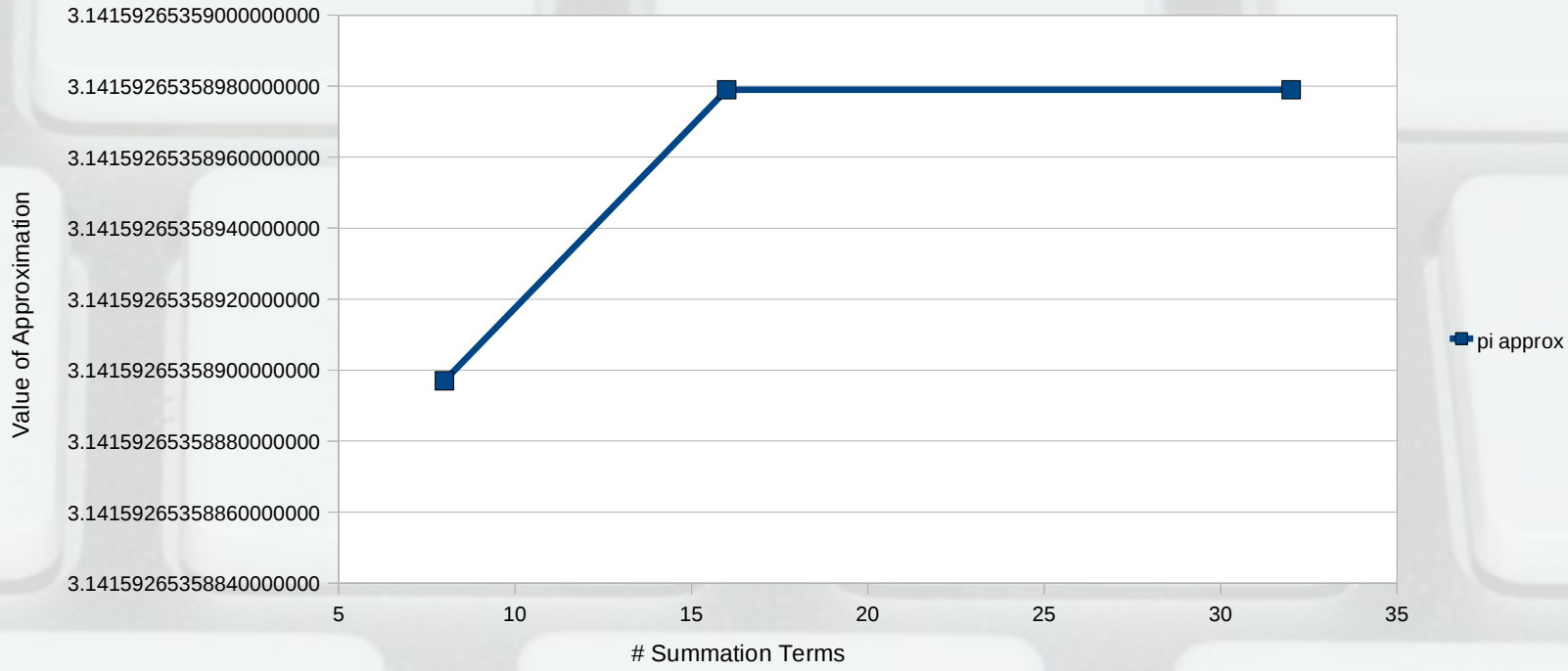
University at Buffalo The State University of New York

cse@buffalo

Dan Padgett

12/17/2009

Accuracy of Approximation



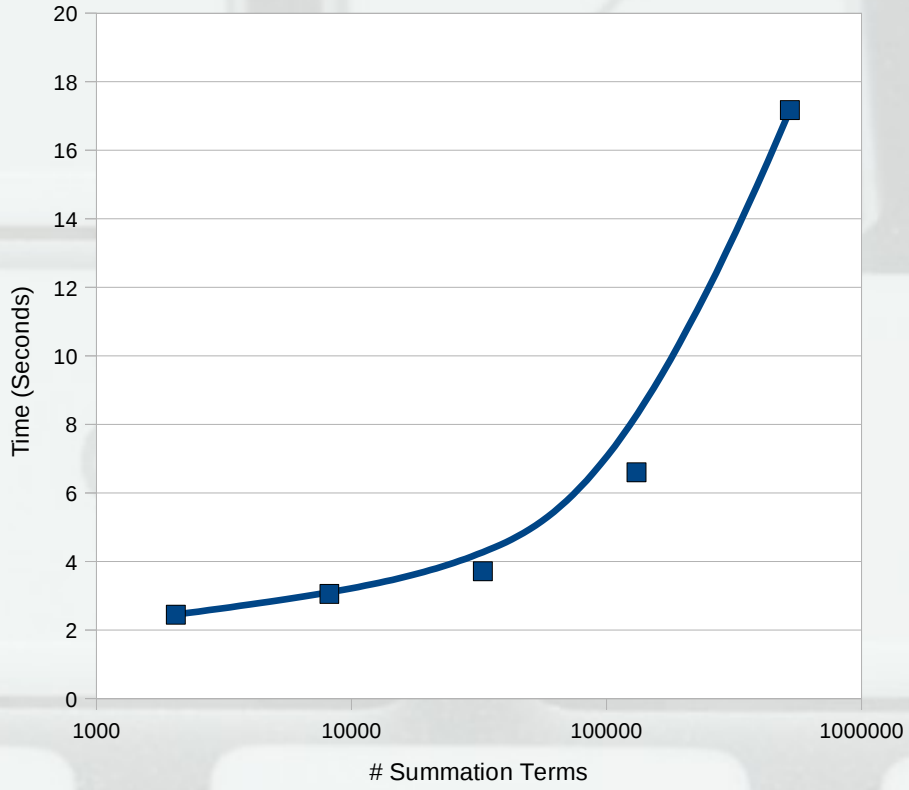
University at Buffalo The State University of New York

cse@buffalo

Dan Padgett

12/17/2009

CUDA Runtime vs Number of Sum Terms



Log Scale!

University at Buffalo The State University of New York

cse@buffalo

Dan Padgett

12/17/2009

Conclusions

- CUDA is not well-suited to problems which require a moderate amount of memory
- For pure computation, CUDA offers enormous speedups through parallelism
- $\pi \approx 3.14$