MCS 572 Project Three : Numerical Integration on a GPU

GPU accelerated composite trapezoidal rule

The goal of the project is to write a GPU accelerated program to approximate a definite integral of a function f over the interval $[a, b]$ with the composite trapezoidal rule:

$$\int_a^b f(x)dx \approx \frac{h}{2}\left(f(a) + f(b)\right) + h\sum_{i=1}^{n-1} f(a+ih), \quad h = \frac{b-a}{n}.$$

The cost of the composite trapezoidal rule is dominated by the cost of n function evaluations which can be calculated independently, in parallel. The summation requires synchronization and can be organized to run in $\log_2(n)$ stages.

Assignment One: write a GPU accelerated program

Write your program to work for general functions.

As a test case, consider the approximation of π via $\frac{\pi}{4} = \int_0^1 \sqrt{1-x^2}dx$.

Assignment Two: demonstrate the correctness

Demonstrate the correctness by giving sample input and outputs.

One good test case is to take a highly oscillatory function, such as $\sin(k2\pi t)$ for $t \in [0, 1]$, which has an increasing frequency for increasing values of k. As k grows, then n (the number of subintervals of $[a, b]$) should increase as well.

Assignment Three: investigate the performance

Experimentally, compare the times of your GPU accelerated program with a run against a version on the CPU. Do runs with various degrees and thread configurations.

Make a table, doubling the values of n each time.

Explain the run times comparing to the theoretical peak performance of the graphics card and identify the bottlenecks in your code.

Consider the application of double double and quad double arithmetic.

The deadline is Monday 25 November 2024 at noon

Submit your answer to the assignments and supporting source code via gradescope.

You may work individually or in pairs on this project. For each pair, please submit only one solution.

If you have questions or difficulties, feel free to email `janv@uic.edu` for an online office hour.

MCS 572 Final Project : some guidelines

a supercomputing research project

This final project is an alternative to project three. The goal of a final project is to apply what you learned in this course for a research topic that is close to your current interests. This could be related to what you do for your own PhD dissertation.

The final project is an individual project.

There are four deadlines:

1. Wednesday 6 November 2024: selection of a research topic.

   Please email me by 5PM on Wednesday 6 November a short description of your topic.

   Your topic could fit one of these four categories:

   (a) an application with state-of-the-art software;
   (b) write your own implementation of a parallel algorithm;
   (c) present a case study of a language (e.g.: go) or tool (e.g.: parsl);
   (d) study fundamental concepts, see the encyclopedia of parallel computing.

   Inspiration for projects could be found at supercomputing conferences, listed below:

   (a) The International Conference for High Performance Computing, Networking, Storage, and Analysis. SC Conference Series.
   (b) The IEEE International Parallel and Distributed Processing Symposium.
   (c) SIAM Conference on Parallel Processing for Scientific Computing.
   (d) NVDIA GPU Technology Conference.

   While a one paragraph description will suffice, please note that in your final technical report, you must provide a more elaborate description about the problem statement.

   In addition to the problem description, state the goals of what you want to accomplish with the parallel implementation. For example, do you want to prototype a novel parallel algorithm, or, in case you work with established codes, do you target specific benchmarks, for which supercomputing is required?

2. Monday 25 November 2024: a rough draft of a technical report.

   The rough draft of a technical report should help you to prepare your oral presentation. While the draft itself may still be rough – it could be in the format of a slide presentation – the problem definition should be precise and clear. Refer to the problems discussed in the course.

3. Monday 2 December - Friday 6 December 2024: oral presentation.

   If everybody chooses for a final project, then oral in class presentations will already start on Monday 2 December. If there is a final exam, then Monday 2 December will be devoted on reviewing topics for the final exam.

   Although later dates are often more popular, please note that after your presentation you will receive feedback and presenting earlier gives you more time to correct and react to the feedback.

4. Tuesday 10 December at 8AM (***Tentative*** date/time of the final exam): deadline for the technical report. This deadline coincides with the time of the final exam.

   The report should contain at least three elements:

   (a) a detailed problem statement;
   (b) methodology, choice of technology, and implementation;
   (c) performance analysis.