TP 5: Mandelbrot Set Computation with OpenMP

November 9, 2023

Introduction

The Mandelbrot set is a famous fractal in mathematics, defined by iterating a simple mathematical function in the complex plane. In this assignment, you will implement a Mandelbrot set computation using c++ , parellize the code using OpenMP and analyze its performance.

Mandelbrot Set Definition

The Mandelbrot set is defined by iterating the following equation:

$$Z_{n+1} = Z_n^2 + C$$

where Z and C are complex numbers. The set is generated by iterating this equation for each point in the complex plane. The number of iterations before the orbit escapes the circle of radius 2 determines whether the point is part of the set.
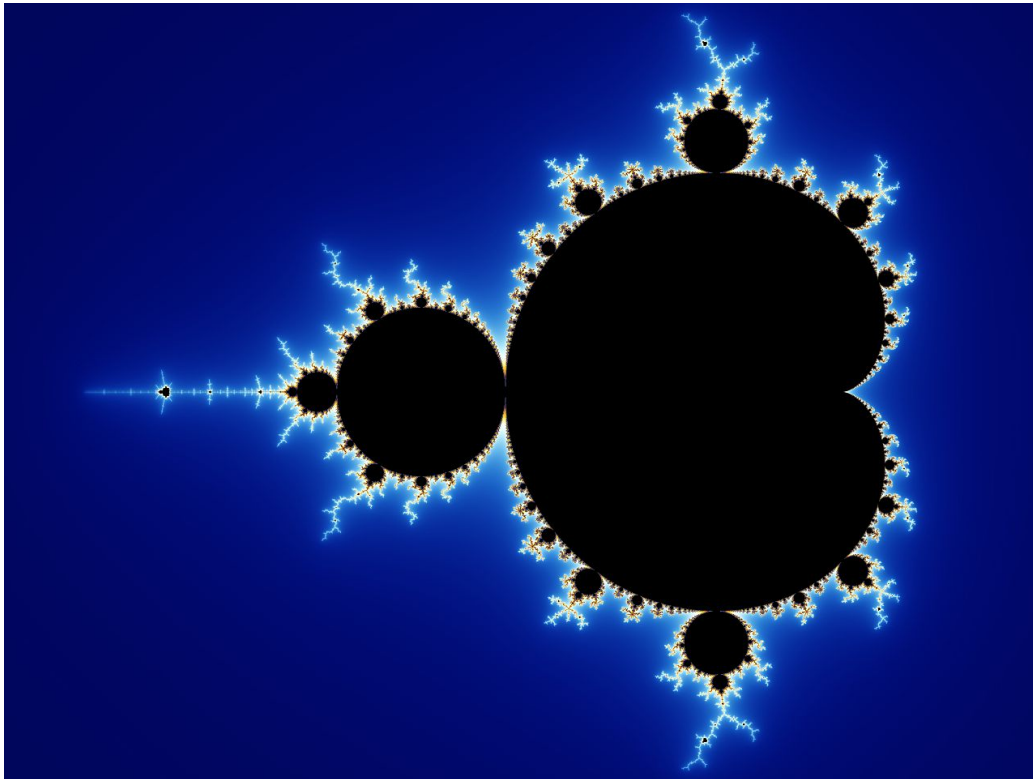
Figure 1: The Mandelbrot set

Task Description

Implementation

Your task is to write a parallelized Mandelbrot set computation code using OpenMP. The code should generate the set for a given region of the complex plane, discretized into a 1000x1000 grid. The maximum number of iterations should be bounded by 256. A code excerpt is provided below

```
...

    double x_scale = (frac_br.x - frac_tl.x) / 1000.;
    double y_scale = (frac_br.y - frac_tl.y) / 1000.;

        for (int y = 0; y < 1000; y++)
        {
```

```
 8              for (int x = 0; x < 1000; x++)
 9              {
10                  std::complex<double> c(x * x_scale + frac_tl.
    x, y * y_scale + frac_tl.y);
11                  std::complex<double> z(0, 0);
12
13                  int n = 0;
14                  while (abs(z) < 2.0 && n < iterations)
15                  {
16                      z = (z * z) + c;
17                      n++;
18                  }
19
20                  pFractal[y * 1000 + x] = n;
21              }
22          }
23 ...
```
Listing 1: Code excerpt for mandelbrot set

OpenMP Parallelization

Use OpenMP to parallelize your code. Vary the number of threads from 2^1 to 2^8 and measure the execution time for each configuration.

Region Variation Experiment

Change the region given by frac_tl = $\{x_1, y_1\}$ (top left) and frac_br = $\{x_2, y_2\}$ (bottom right) for three different regions of your choice. Study the execution time for a fixed number of processors (2^4) and explain the differences observed.
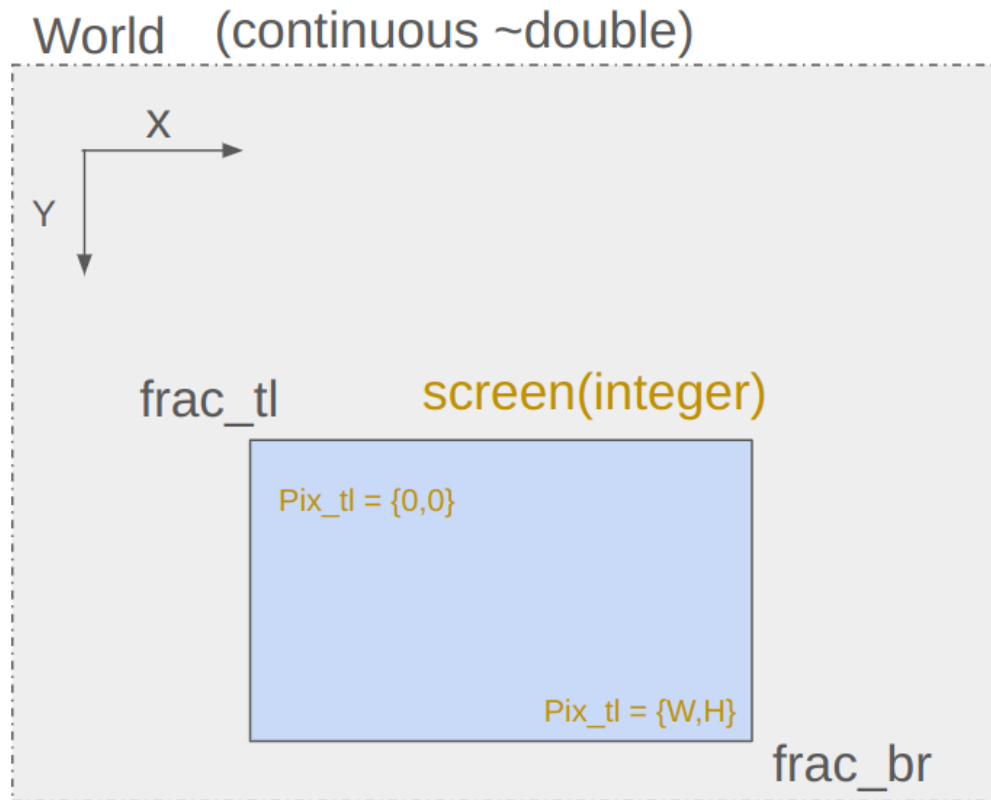
Figure 2: Locating a region in the complex plane (World)

Report Requirements

Submit a report along with your code. The report should include:

- Introduction

- Methodology (Brief explanation of your code structure and OpenMP implementation)

- Results (Include execution time graphs for different thread configurations)

- Discussion (Explain any observed scaling behavior and performance differences)

- Conclusion

Submission

Submit your code along with the report. don't forget the Makefile