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CS6068

Assignment #4

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# Introduction

The goal of this assignment was to practice the workflow of compiling and running CUDA code and to write CUDA code to generate an image in parallel. The enum\_gpu.cu code taken from *CUDA by Example: An Introduction to General-Purpose GPU Programming* was executed on a Pitzer Desktop on the Ohio Supercomputer Center (OSC) to practice compiling and running CUDA code. The starter code taken from *CUDA by Example: An Introduction to General-Purpose GPU Programming*, julia\_gpu.cu, generated an image of the Julia Set. This CUDA code was modified to generate an image of the Mandelbrot Set by initially setting the exponential component of the iterative function equal to zero.

# Tools

* julia\_set\_modified.cu
* CUDA
* Pitzer Desktop (1 GPU, 48 Cores, 1 Visualization Node)

# Code

/\*

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#include "../common/book.h"

#include "../common/cpu\_bitmap.h"

#define DIM 1000

struct cuComplex {

    float   r;

    float   i;

   \_\_device\_\_ cuComplex( float a, float b ) : r(a), i(b)  {}

    \_\_device\_\_ float magnitude2( void ) {

        return r \* r + i \* i;

    }

    \_\_device\_\_ cuComplex operator\*(const cuComplex& a) {

        return cuComplex(r\*a.r - i\*a.i, i\*a.r + r\*a.i);

    }

    \_\_device\_\_ cuComplex operator+(const cuComplex& a) {

        return cuComplex(r+a.r, i+a.i);

    }

};

\_\_device\_\_ int julia( int x, int y ) {

    const float scale = 1.5;

    float jx = scale \* (float)(DIM/2 - x)/(DIM/2);

    float jy = scale \* (float)(DIM/2 - y)/(DIM/2);

    cuComplex c(jx, jy);

    cuComplex a(0, 0);

    int i = 0;

    for (i=0; i<200; i++) {

        a = a \* a + c;

        if (a.magnitude2() > 1000)

            return 0;

    }

    return 1;

}

\_\_global\_\_ void kernel( unsigned char \*ptr ) {

    // map from blockIdx to pixel position

    int x = blockIdx.x;

    int y = blockIdx.y;

    int offset = x + y \* gridDim.x;

    // now calculate the value at that position

    int juliaValue = julia( x, y );

    ptr[offset\*4 + 0] = 255 \* juliaValue;

    ptr[offset\*4 + 1] = 0;

    ptr[offset\*4 + 2] = 0;

    ptr[offset\*4 + 3] = 255;

}

// globals needed by the update routine

struct DataBlock {

    unsigned char   \*dev\_bitmap;

};

int main( void ) {

    DataBlock   data;

    CPUBitmap bitmap( DIM, DIM, &data );

    unsigned char    \*dev\_bitmap;

    HANDLE\_ERROR( cudaMalloc( (void\*\*)&dev\_bitmap, bitmap.image\_size() ) );

    data.dev\_bitmap = dev\_bitmap;

    dim3    grid(DIM,DIM);

    kernel<<<grid,1>>>( dev\_bitmap );

    HANDLE\_ERROR( cudaMemcpy( bitmap.get\_ptr(), dev\_bitmap,

                              bitmap.image\_size(),

                              cudaMemcpyDeviceToHost ) );

    HANDLE\_ERROR( cudaFree( dev\_bitmap ) );

    bitmap.display\_and\_exit();

}

# Results

First, enum\_gpu.cu was executed on the Pitzer Desktop. The Pitzer Desktop had 80 multiprocessors and 49,152 bytes of shared memory per multiprocessor. The results are shown in Figure 1. Second, the starter code from the textbook was executed. The starter code generated an image of the Julia Set in parallel. The generated image of the Julia Set is shown in Figure 2. Third, the modified CUDA code, julia\_set\_modified.cu, was executed. The generated image of the Mandelbrot Set is shown in Figure 3. This CUDA code was modified to generate an image of the Mandelbrot Set by initially setting the exponential component of the iterative function equal to zero.

A screenshot of a computer

Description automatically generated

Figure 1: enum\_gpu.cu Output

A red swirls on a black background

Description automatically generated

Figure 2: Generated Image of Julia Set

A red circle with black background

Description automatically generated

Figure 3: Generated Image of Mandelbrot Set

# Conclusion

The enum\_gpu.cu code taken from *CUDA by Example: An Introduction to General-Purpose GPU Programming* was executed on a Pitzer Desktop on the Ohio Supercomputer Center (OSC) to practice compiling and running CUDA code. The starter code taken from *CUDA by Example: An Introduction to General-Purpose GPU Programming*, julia\_gpu.cu, generated an image of the Julia Set. This CUDA code was modified to generate an image of the Mandelbrot Set by initially setting the exponential component of the iterative function equal to zero.