并行与分布式作业 六

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> *实验环境：**Windows10 + Visual Studio 2019 + CUDA 11.0***

CUDA-homework-1

> Start from the provided skeleton code `error-test.cu` that provides some convenience macros for error checking. The macros are defined in the header file `error_checks_1.h` . Add the missing memory allocations and copies and the kernel launch and check that your code works.
>
> 1. What happens if you try to launch kernel with too large block size? When do you catch the error if you remove the `cudaDeviceSynchronize()` call?
> 2. What happens if you try to dereference a pointer to device memory in host code?
> 3. What if you try to access host memory from the kernel?
>
> Remember that you can use also cuda-memcheck! If you have time, you can also check what happens if you remove all error checks and do the same tests again.

1. 代码完善

- 核函数

  `vector_add` 函数就用原来的就可以，不用更改

```
__global__ void vector_add(double* C, const double* A, const double* B, int N)
{
    // Add the kernel code
    int idx = blockIdx.x * blockDim.x + threadIdx.x;
    // Do not try to access past the allocated memory
    if (idx < N) {
        C[idx] = A[idx] + B[idx];
    }
}
```

- 在 `host` 上申请内存，拷贝到 `device`

```
/*
   Add memory allocations and copies. Wrap your runtime function
   calls with CUDA_CHECK( ) macro
*/
CUDA_CHECK(cudaMalloc((void**)&dA, sizeof(double) * N));
CUDA_CHECK(cudaMalloc((void**)&dB, sizeof(double) * N));
CUDA_CHECK(cudaMalloc((void**)&dC, sizeof(double) * N));
CUDA_CHECK(cudaMemcpy(dA, hA, sizeof(double) * N, cudaMemcpyHostToDevice));
CUDA_CHECK(cudaMemcpy(dB, hB, sizeof(double) * N, cudaMemcpyHostToDevice));
```

- 核函数调用

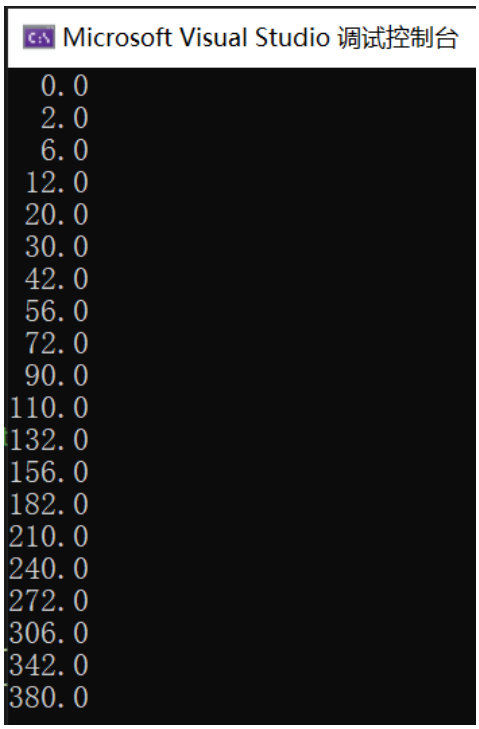
```
//// Add the kernel call here
vector_add<<<1,16>>>(dC, dA, dB, N);
```

- 最后将结果拷贝回host，然后释放

```
//// Copy back the results and free the device memory
CUDA_CHECK(cudaMemcpy(hC, dC, sizeof(double) * N, cudaMemcpyDeviceToHost));
CUDA_CHECK(cudaFree(dA));
CUDA_CHECK(cudaFree(dB));
CUDA_CHECK(cudaFree(dC));
```

2. 运行

直接在VS里运行：



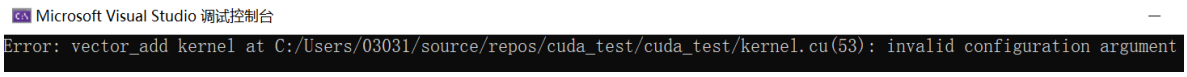
可以看到将结果都输出且均正确。

> What happens if you try to launch kernel with too large block size?

将核函数调用如下更改：

```
vector_add<<<1,2048>>>(dC, dA, dB, N);
```

可以看到如下报错：



> When do you catch the error if you remove the `cudaDeviceSynchronize()` call?

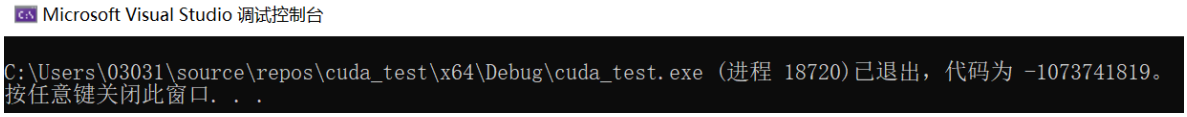
结果没有变化，没有报错。

> What happens if you try to dereference a pointer to device memory in host code?

添加以下代码：

```
dA[0] = 1;
dB[0] = 1;
dC[0] = 1;
```

运行后直接报错：



> What if you try to access host memory from the kernel?

我定义了一个全局变量，并在核函数中让此变量加一，编译时出现如下错误：

CUDA-homework-2

> In this exercise we will implement a Jacobi iteration which is a very simple finite-difference scheme. Familiarize yourself with the provided skeleton. Then implement following things:
>
> 1. Write the missing CUDA kernel `sweepGPU` that implements the same algorithm as the `sweepCPU` function. Check that the reported averate difference is in the order of the numerical accuracy.
> 2. Experiment with different grid and block sizes and compare the execution times.

- 根据串行的代码可以写出如下的核函数：

```
// GPU kernel
__global__
void sweepGPU(double* phi, const double* phiPrev, const double* source,
    double h2, int N)
{
    int i = blockIdx.x * blockDim.x + threadIdx.x;
    int j = blockIdx.y * blockDim.y + threadIdx.y;
    if (i > 0 && j > 0 && i < N - 1 && j < N - 1) {
        int index = i + j * N;
        int i1 = (i - 1) + j * N;
        int i2 = (i + 1) + j * N;
        int i3 = i + (j - 1) * N;
        int i4 = i + (j + 1) * N;
        phi[index] = 0.25 * (phiPrev[i1] + phiPrev[i2] + phiPrev[i3] +
phiPrev[i4] - h2 * source[index]);
```

```
    }
}
```

- 核函数的调用：

```
sweepGPU<<<dimGrid, dimBlock>>>(phiPrev_d, phi_d, source_d, h * h, N);
sweepGPU<<<dimGrid, dimBlock>>>(phi_d, phiPrev_d, source_d, h * h, N);
```

- 将结果拷贝回host

```
CUDA_CHECK( cudaMemcpy(phi, phi_d, size, cudaMemcpyDeviceToHost));
CUDA_CHECK( cudaMemcpy(phiPrev, phiPrev_d, size, cudaMemcpyDeviceToHost));
```

- 将内存释放掉

```
CUDA_CHECK( cudaFree(phi_d));
CUDA_CHECK( cudaFree(phiPrev_d));
CUDA_CHECK( cudaFree(source_d));
```

- 运行

```
Microsoft Visual Studio 调试控制台
100 0.00972858
200 0.00479832
300 0.00316256
400 0.00234765
500 0.00186023
600 0.00153621
700 0.0013054
800 0.00113277
900 0.000998881
1000 0.000892078
1100 0.00080496
1200 0.000732594
1300 0.000671564
1400 0.000619434
1500 0.000574415
1600 0.000535167
1700 0.000500665
1800 0.000470113
CPU Jacobi: 2.93 seconds, 1800 iterations
100 0.00972858
200 0.00479832
300 0.00316256
400 0.00234765
500 0.00186023
600 0.00153621
700 0.0013054
800 0.00113277
900 0.000998881
1000 0.000892078
1100 0.00080496
1200 0.000732594
1300 0.000671564
1400 0.000619434
1500 0.000574415
1600 0.000535167
1700 0.000500665
1800 0.000470113
GPU Jacobi: 0.318 seconds, 1800 iterations
Average difference is 6.27744e+66

C:\Users\03031\source\repos\Jocabi\x64\Debug\Jocabi.exe (进程 9644)已退出，代码为 0。
按任意键关闭此窗口. . .
```

> Experiment with different grid and block sizes and compare the execution times.

- `block sizes=1`

```
GPU Jacobi: 3.12 seconds, 1800 iterations
```

- `block sizes=2`

```
GPU Jacobi: 1.09 seconds, 1800 iterations
```

- `block sizes=4`

```
GPU Jacobi: 0.458 seconds, 1800 iterations
```

- `block sizes=8`

```
GPU Jacobi: 0.31 seconds, 1800 iterations
```

- `block sizes=16`

```
GPU Jacobi: 0.293 seconds, 1800 iterations
```

- `block sizes=32`

```
GPU Jacobi: 0.33 seconds, 1800 iterations
```

可以看到，当`block sizes`增加时，运行时间先减小后小幅增加。

实验总结

本次实验是我第一次上手写CUDA程序， 总体来说还算顺利，加深了我对CUDA编程方法的理解，更加熟练了。