Practice

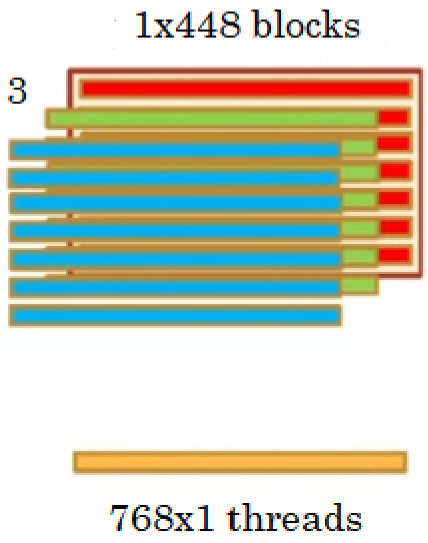


Figure 1: img

Lab 13

Write a program in c/c++ using CUDA in which you implement a kernel to calculate an RGB image complement. The kernel must be verified, consider the requirements:

- The complement of an image is defined as:

I(x,y) = 255 - I(x,y)

- Blocks of 768 x 1 threads.
- A grid of 1 x 448 x 3 blocks.
- The kernel signature should be: `__global__ void complement(uchar* RGB)`
- The CPU complement function signature should be: `__host__ void complementCPU(Mat* original, Mat* comp)`
- The kernel validation signature should be: `__host__ bool validationKernel(Mat img1, Mat img2)`

Solution

```
#include "cuda_runtime.h"
#include "device_launch_parameters.h"

#include <stdio.h>
```

```
#include <stdlib.h>
#include <opencv2/opencv.hpp>

using namespace cv;

__host__ void checkCUDAError(const char* msg) {
    cudaError_t error;
    cudaDeviceSynchronize();
    error = cudaGetLastError();
    if (error != cudaSuccess) {
        printf("ERROR %d: %s (%s)\n", error,
           cudaGetErrorString(error), msg);
    }
}

__global__ void complement(uchar* RGB) {

    // locate my current block row
    int threads_per_block = blockDim.x;
    int threads_per_row = threads_per_block * gridDim.x;
    int row_offset = threads_per_row * blockIdx.y;

    // locate my current block column
    int block_offset = blockIdx.x * threads_per_block;

    // locate my current grid row
    int thread_per_grid = (gridDim.x * gridDim.y *
       threads_per_block);
    int gridOffset = blockIdx.z * thread_per_grid;

    int gId = gridOffset + row_offset + block_offset +
       threadIdx.x;
    RGB[gId] = 255 - RGB[gId];
}

__host__ void complementCPU(Mat* original, Mat* comp) {
    for (int i = 0; i < original->rows; i++) {
        for (int j = 0; j < original->cols; j++) {
            comp->at<Vec3b>(i, j)[0] = 255 - original->at<
               Vec3b>(i, j)[0];
            comp->at<Vec3b>(i, j)[1] = 255 - original->at<
               Vec3b>(i, j)[1];
            comp->at<Vec3b>(i, j)[2] = 255 - original->at<
               Vec3b>(i, j)[2];
        }
    }
}

__host__ bool validationKernel(Mat img1, Mat img2) {
    Vec3b* pImg1, * pImg2;
    for (int k = 0; k < 3; k++) {
        for (int i = 0; i < img1.rows; i++) {
            pImg1 = img1.ptr<Vec3b>(i);
            pImg2 = img2.ptr<Vec3b>(i);
            for (int j = 0; j < img1.cols; j++) {
                if (pImg1[j][k] != pImg2[j][k]) {
                    printf("Error at kernel validation\n");
                    return true;
                }
            }
        }
    }
    printf("Kernel validation successful\n");
    return false;
}

int main() {

    Mat img = imread("antenaRGB.jpg");

    const int R = img.rows;
    const int C = img.cols;

    Mat imgComp(img.rows, img.cols, img.type());
    Mat imgCompCPU(img.rows, img.cols, img.type());
    uchar* host_rgb, * dev_rgb;
    host_rgb = (uchar*)malloc(sizeof(uchar) * R * C * 3);

    cudaMalloc((void**)&dev_rgb, sizeof(uchar) * R * C * 3);
    checkCUDAError("Error at malloc dev_r1");

    // matrix as vector
    for (int k = 0; k < 3; k++) {
        for (int i = 0; i < R; i++) {
            for (int j = 0; j < C; j++) {
                Vec3b pix = img.at<Vec3b>(i, j);

                host_rgb[i * C + j + (k * R * C)] = pix[k];

            }
        }
    }
    cudaMemcpy(dev_rgb, host_rgb, sizeof(uchar) * R * C * 3,
       cudaMemcpyHostToDevice);
    checkCUDAError("Error at memcpy host_rgb -> dev_rgb");

    //dim3 block(32, 32);
    //dim3 grid(C / 32, R / 32, 3); // 24 14
    dim3 block(C, 1, 1); // 768
    dim3 grid(1, R, 3); // 448

    complement << < grid, block >> > (dev_rgb);
    cudaDeviceSynchronize();
    checkCUDAError("Error at kernel complement");

    cudaMemcpy(host_rgb, dev_rgb, sizeof(uchar) * R * C * 3,
       cudaMemcpyDeviceToHost);
    checkCUDAError("Error at memcpy host_rgb <- dev_rgb");

    for (int k = 0; k < 3; k++) {
        for (int i = 0; i < R; i++) {
            for (int j = 0; j < C; j++) {
                imgComp.at<Vec3b>(i, j)[k] = host_rgb[i * C +
                   j + (k * R * C)];
            }
        }
    }

    complementCPU(&img, &imgCompCPU);
    bool error = validationKernel(imgCompCPU, imgComp);

    if (error) {
        printf("Check kernel operations\n");
        return 0;
    }


    imshow("Image", img);
    imshow("Image Complement CPU", imgCompCPU);
    imshow("Image Complement GPU", imgComp);
    waitKey(0);

    free(host_rgb);
    cudaFree(dev_rgb);

    return 0;
}
```

Input

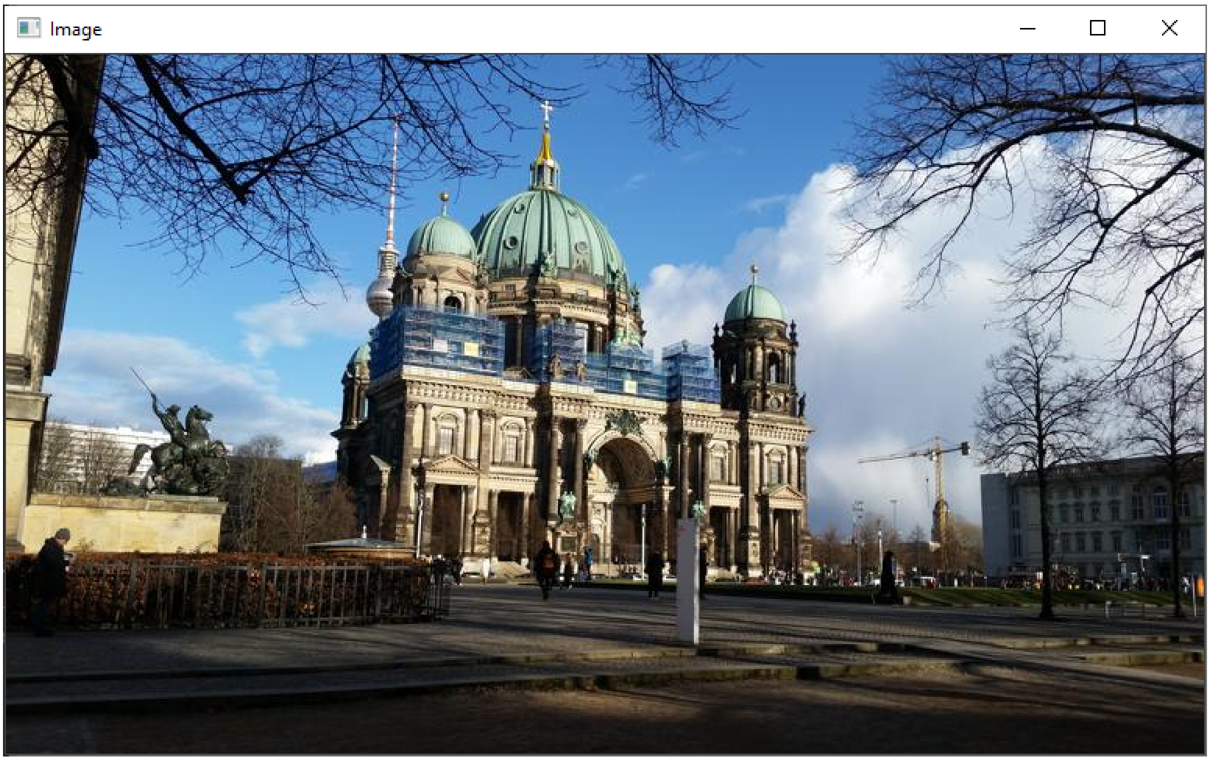


Figure 2: img

Output

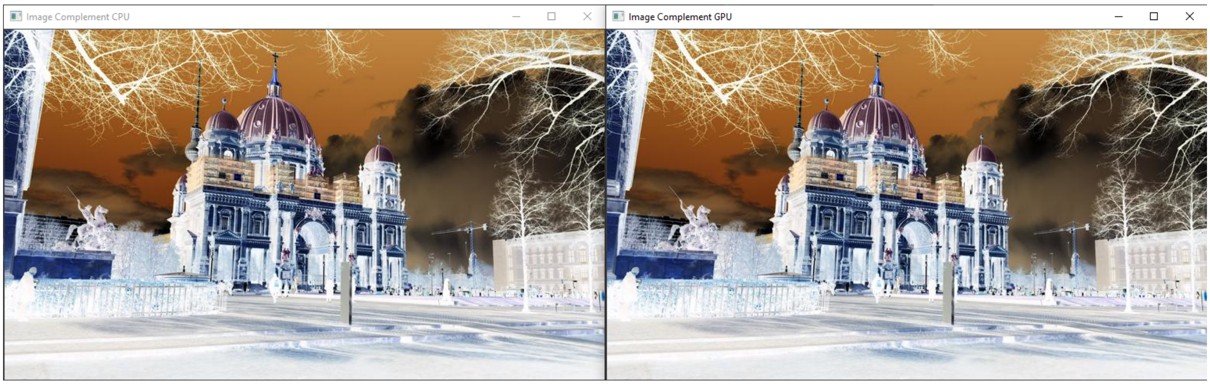
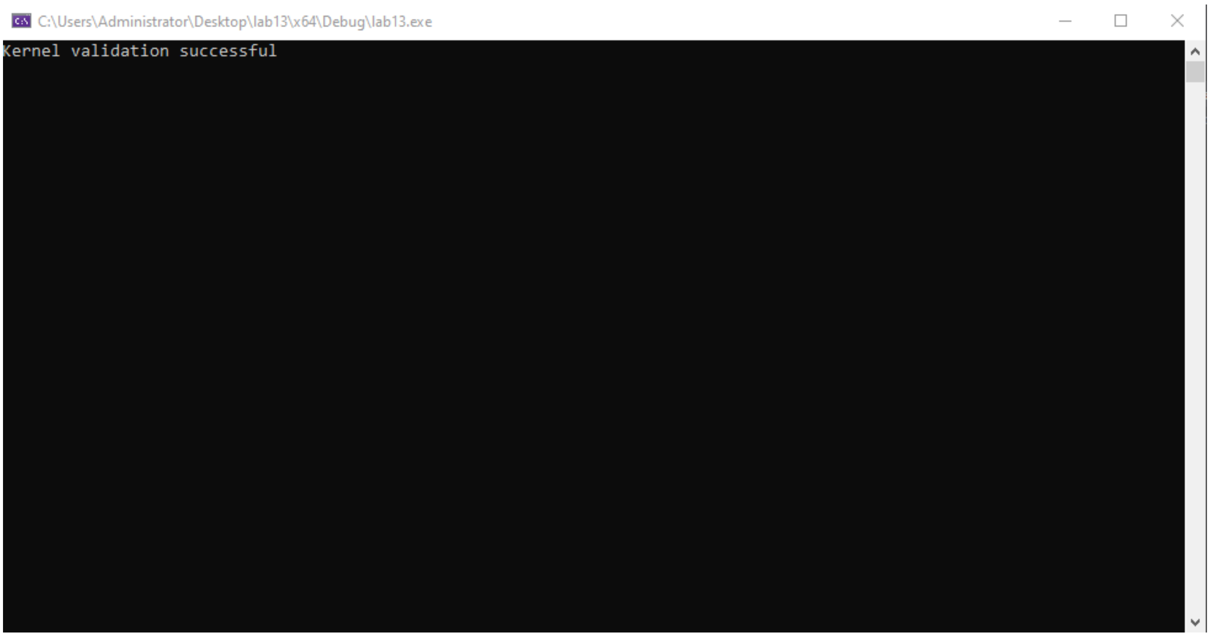


Figure 3: img



```
Kernel validation successful
```

Figure 4: img