Lab4 CUDA Advance

Nov, 2021 Parallel Programming

Overview

- Review
- Coalesced Memory Access
- Lower Precision
- Shared Memory
- Lab4

Review

- In last lab, some of people parallelled the y-axis

```
int y = blockIdx.x * blockDim.x + threadIdx.x;
if (y >= height) return;

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

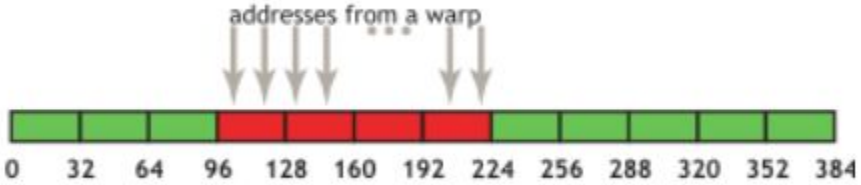
- Launch height / num_threads + 1 blocks

```
// decide to use how many blocks and threads
const int num_threads = 256;
const int num_blocks = height / num_threads + 1;

// launch cuda kernel
sobel << <num_blocks, num_threads>>> (dsrc, ddst, height, width, channels);
```

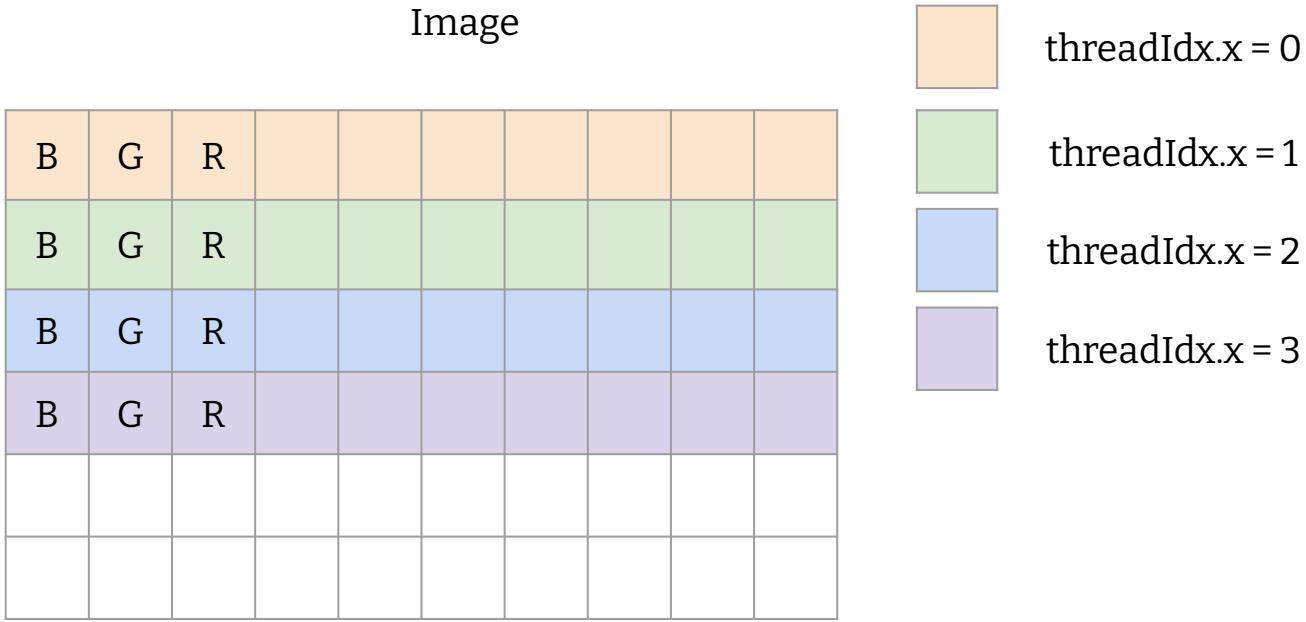
Coalesced Memory Access

- In short,
  - Concurrent memory accesses in a warp are continuous



- Why
  - GPU has L2 (32 bytes), L1 (128 bytes) cache
  - If memory accesses in a warp are continuous, it can utilize the cache
- Details
  - CUDA Best Practices

Problem of Paralleling Y-axis



Better Access Pattern

- In thread level, we should parallel x-axis
  - Different with CPU
- How to parallel y-axis and x-axis
  - Use block to parallel y
  - Launch 2D block
  - Combine both

Block & Threads

```
// decide to use how many blocks and threads
const int num_threads = 256;
const int num_blocks = 2048;

// launch cuda kernel
sobel << <num_blocks, num_threads>>> (dsrc, ddst, height, width, channels);
```

```
for (int y = blockIdx.x; y < height; y += gridDim.x) {
    for (int x = threadIdx.x; x < width; x += blockDim.x) {
    /* Z axis of filter */
```

2D Block

```
// Dim3 var(number of x, number of y)
dim3 num_threads(128, 4);
const int num_blocks = 2048;

// launch cuda kernel
sobel << <num_blocks, num_threads>>> (dsrc, ddst, height, width, channels);
```

```
for (int y = blockIdx.x * blockDim.y + threadIdx.y; y < height; y += gridDim.x * blockDim.y) {
    for (int x = threadIdx.x; x < width; x += blockDim.x) {
```

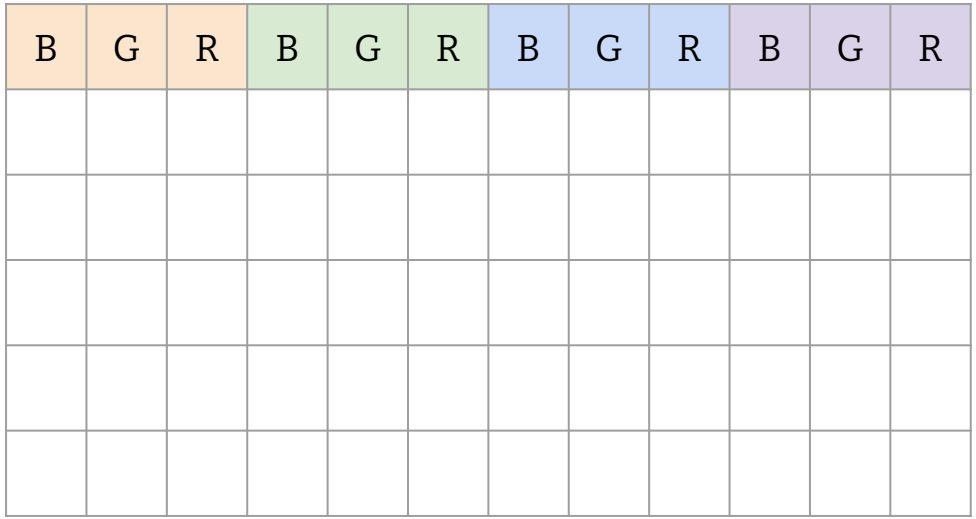
2D Block & 2D threads

```
// Dim3 var(number of x, number of y)
dim3 num_threads(128, 4);
dim3 num_blocks(1, 2048);
```

Practice x, y index by yourself

Coalesced Memory Access

Image



threadIdx.x = 0

threadIdx.x = 1

threadIdx.x = 2

threadIdx.x = 3

3 bytes * 32 threads = 96 bytes

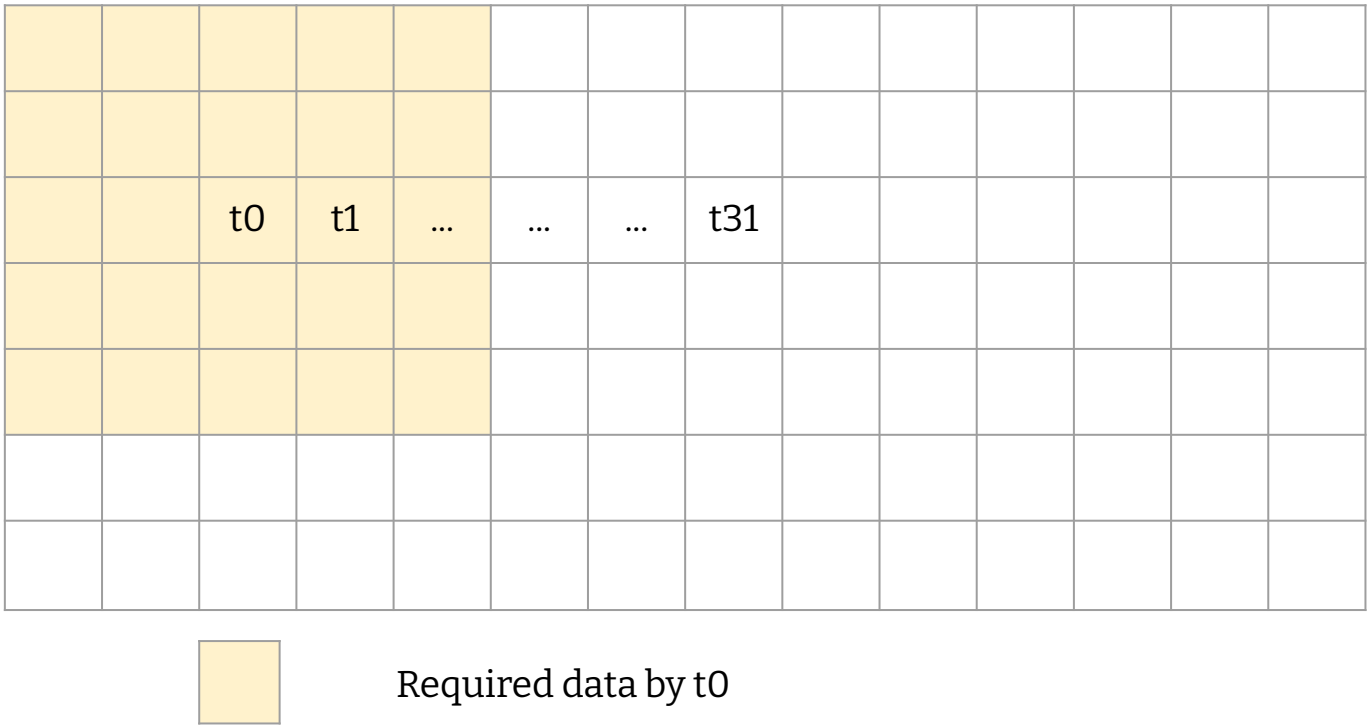
Mixed-Precision

- Use lower precision when available
- Use float to replace double
- Use fp16 to replace float
- Make sure using lower precision does not affect the results

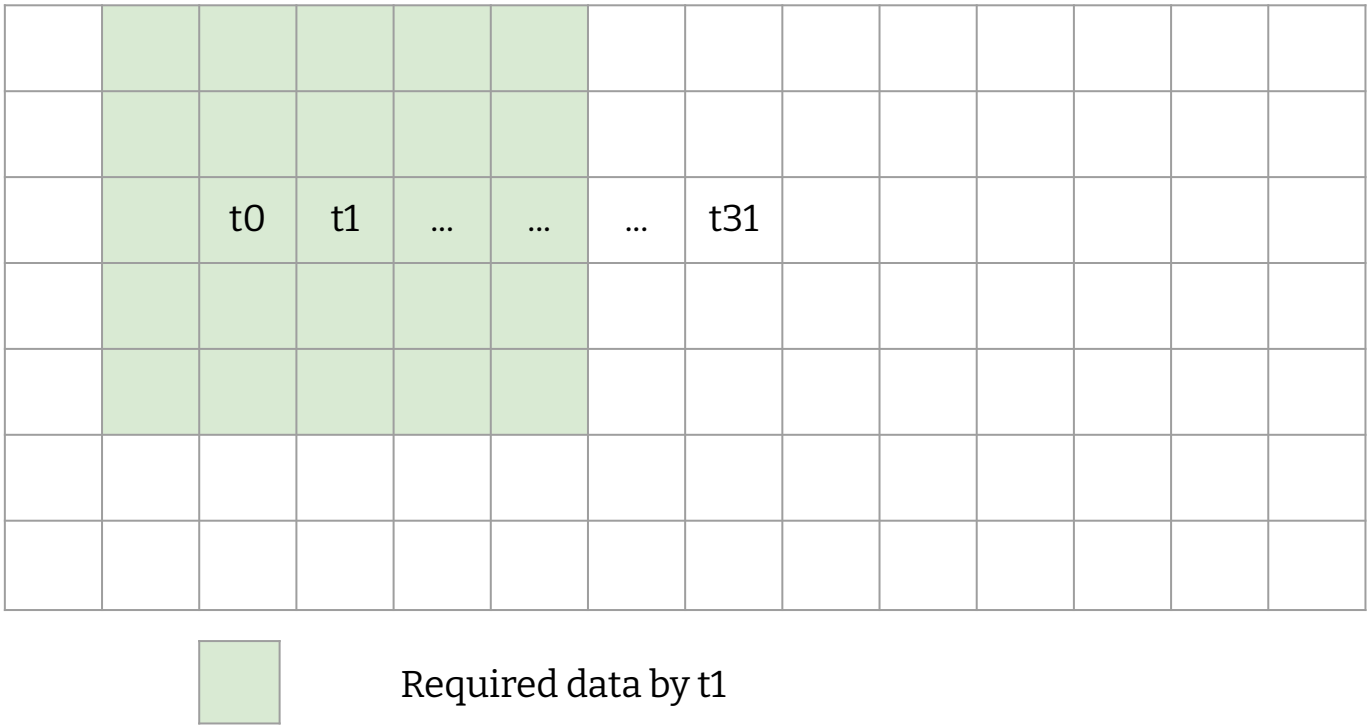
Shared Memory

- Shared memory is powerful when the data has locality
- Convolution is a good case

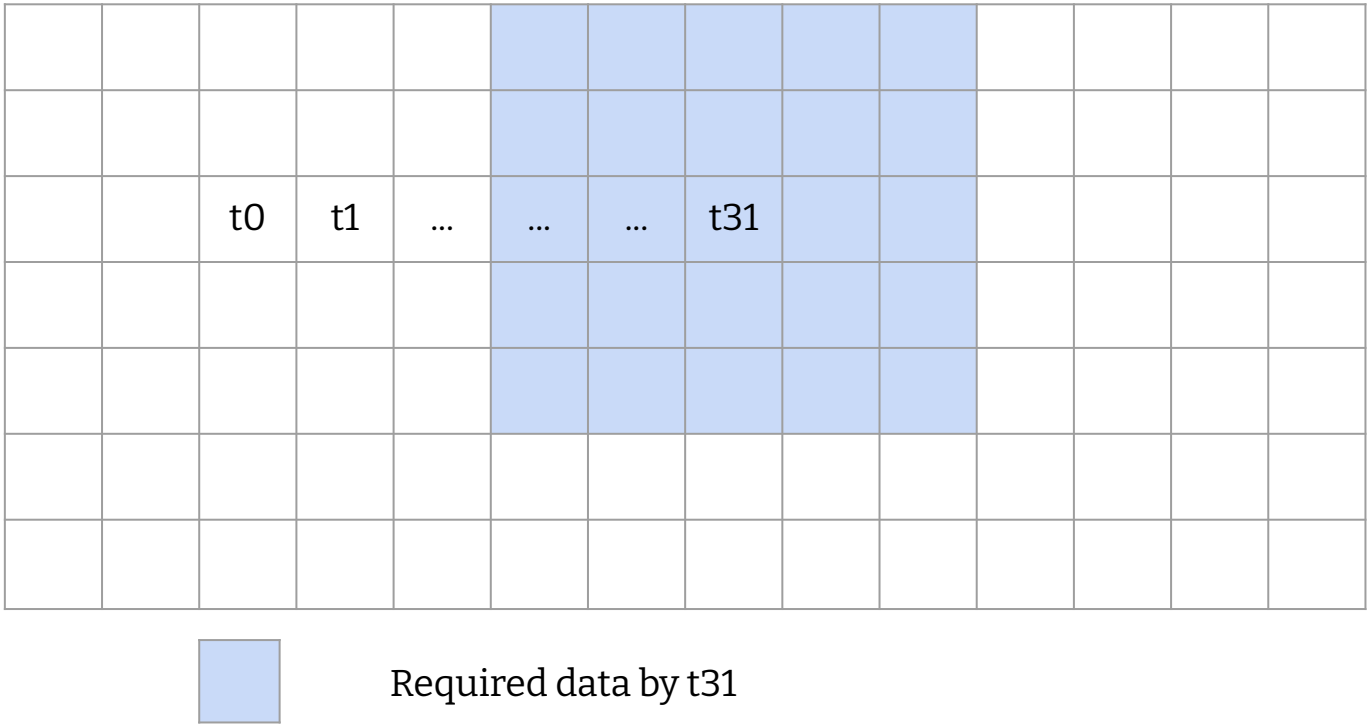
Shared Memory with Sobel



Shared Memory with Sobel

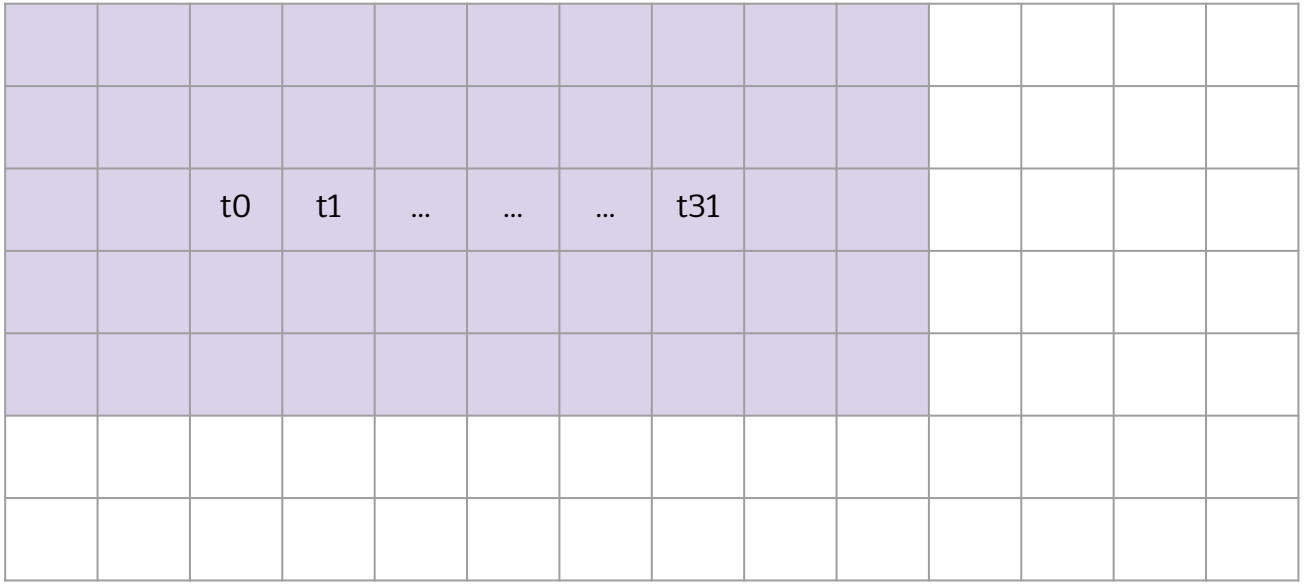


Shared Memory with Sobel



Using Shared Memory in Sobel

- Move the required data into shared memory
- Compute
- Update shared memory



Lab4

- Optimize the sobel CUDA implementation
- TAs provide simple CUDA version
  - You are asked to accelerate it over **13x**
  - Materials are under **/home/pp21/share/lab4**
- Name your kernel as “sobel”
- We accept little pixel errors

Submission

- Finish it before 12/2 23:59
- Submit your code and Makefile (optional) to eeclass
- You can use **lab4-judge** for pre-check