HW3
Sobel Operator

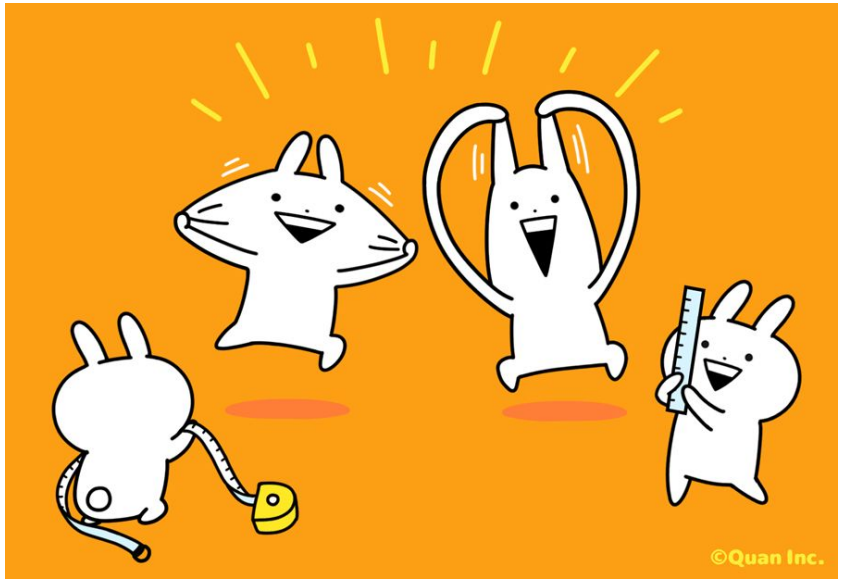
Introduction to Parallel Computing
2022/03/29

Spec

- https://hackmd.io/@ipc22/hw3

Sobel: Edge Detection

Edge Detection: Identifying points in a digital image at which the image brightness changes sharply



Sobel: Edge Detection

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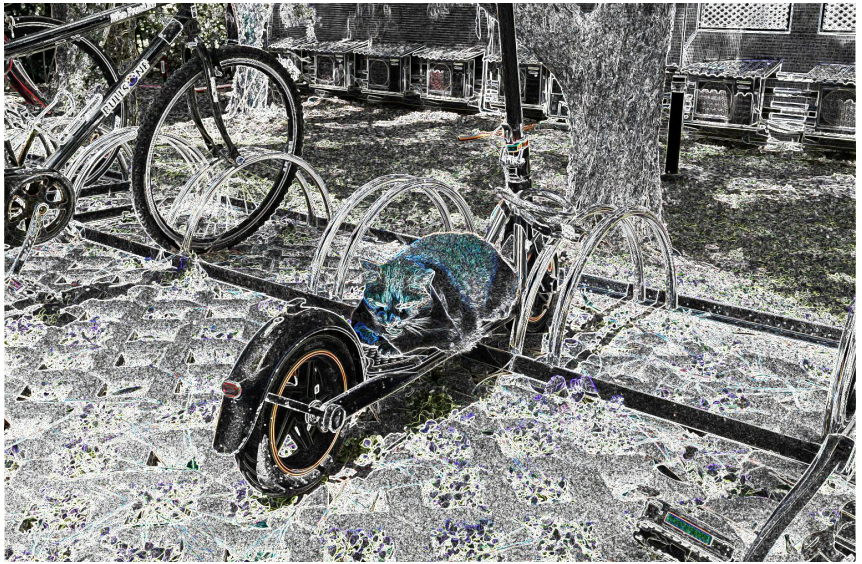

Sobel: Edge Detection

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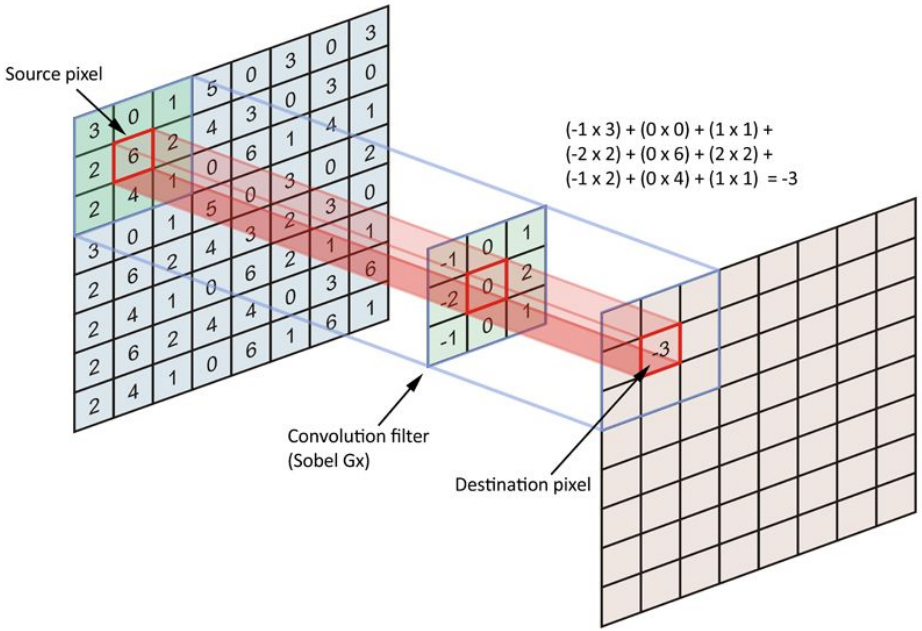
Sobel: Edge Detection



Credit: https://soubhihadri.medium.com/image-processing-best-practices-c-part-2-c0988b2d3e0c

5x5 Kernel

We will use this kernel in this homework.

$$g_x = \begin{pmatrix} -1 & -2 & 0 & 2 & 1 \\ -4 & -8 & 0 & 8 & 4 \\ -6 & -12 & 0 & 6 & 12 \\ -4 & -8 & 0 & 8 & 4 \\ -1 & -2 & 0 & 2 & 1 \end{pmatrix},$$

$$g_y = \begin{pmatrix} -1 & -4 & -6 & -4 & -1 \\ -2 & -8 & -12 & -8 & -2 \\ 0 & 0 & 0 & 0 & 0 \\ 2 & 8 & 12 & 8 & 2 \\ 1 & 4 & 6 & 4 & 1 \end{pmatrix}$$

Your task

- The code on `hades:/home/ipc22/share/hw3/sobel.cc` implements the sobel operator in CPU.
- Your task is to use CUDA to parallelize it.
- Refer to the detailed spec for I/O formats and requirements.

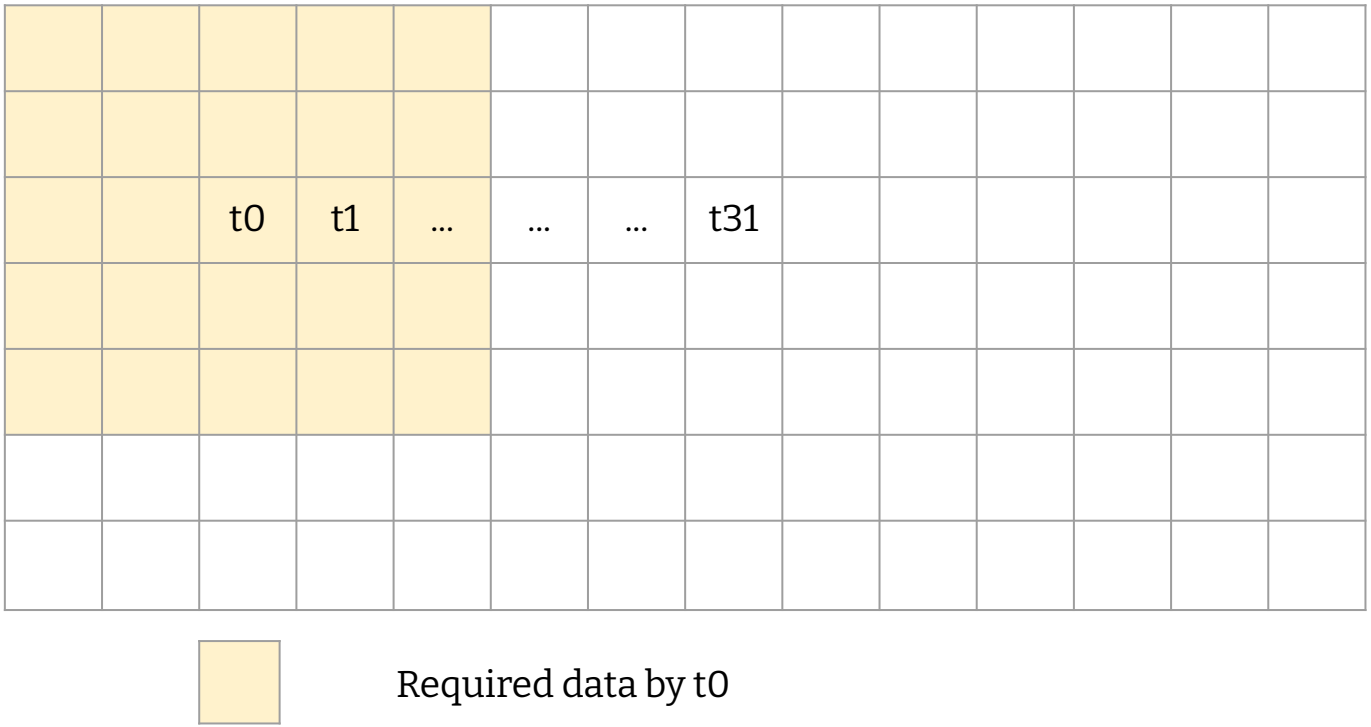
Steps

- Malloc memory on GPU
- Copy original image to GPU
- Put filter matrix on device memory (or declare it on device)
- Copy filter matrix to shared memory (don’t let only one thread do it)
- Parallel the sobel computing
- Copy the results from device to host
- Free unused address

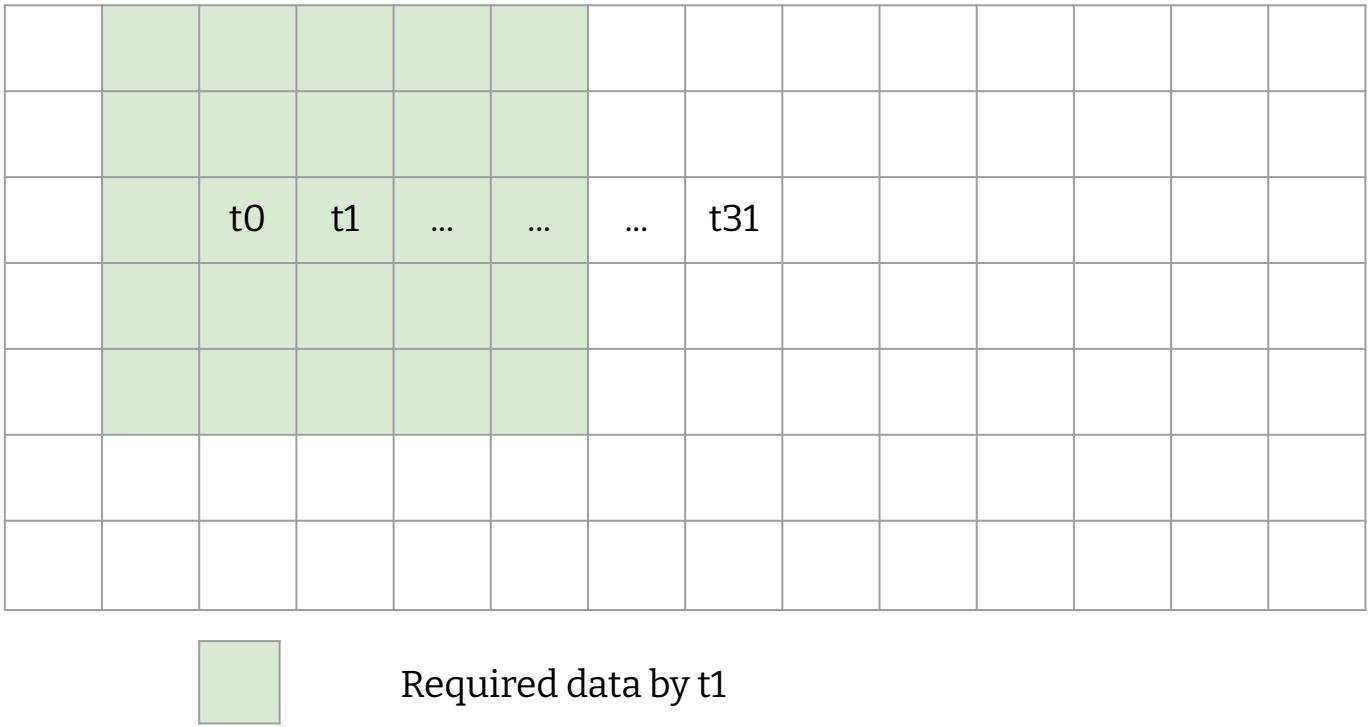
Optimization Hint

- Shared Memory
- Coalesced Memory Access
- Lower Precision
- 2D Block & 2D threads
- CUDA Best Practices
- I/O optimization

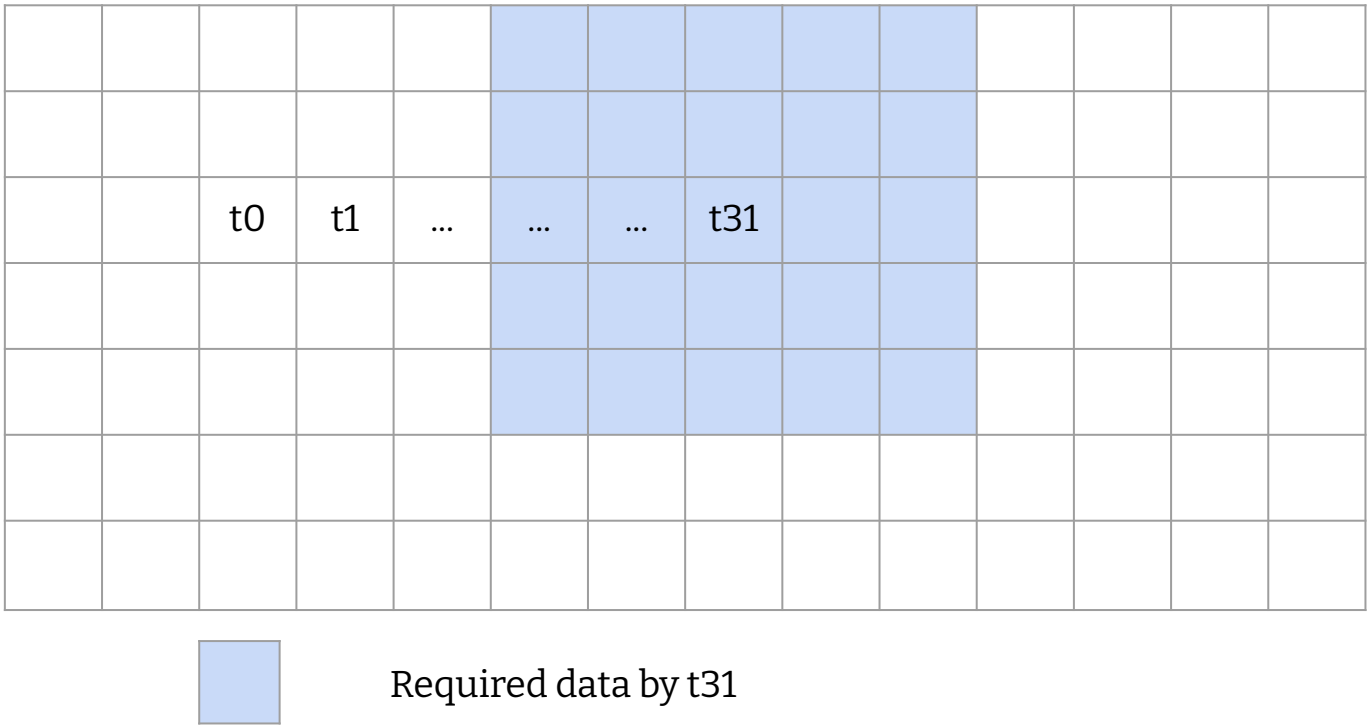
Shared Memory with Sobel



Shared Memory with Sobel

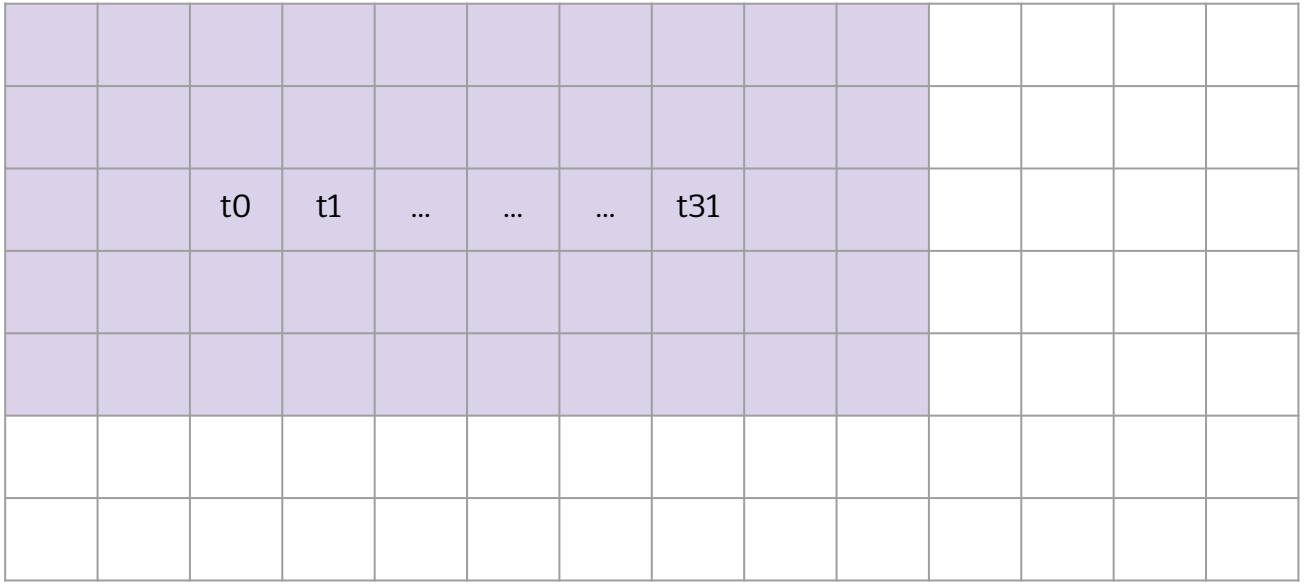


Shared Memory with Sobel



Using Shared Memory in Sobel

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



nvprof

- A CUDA profiler provides feedback to optimize CUDA programs.
- Run on hades02 or use slurm to launch the job.
- `nvprof ./hw3 in.png out.png`
- Show kernel execution time in the report.