Lab3 CUDA Basic

Nov, 2021 Parallel Programming

Overview

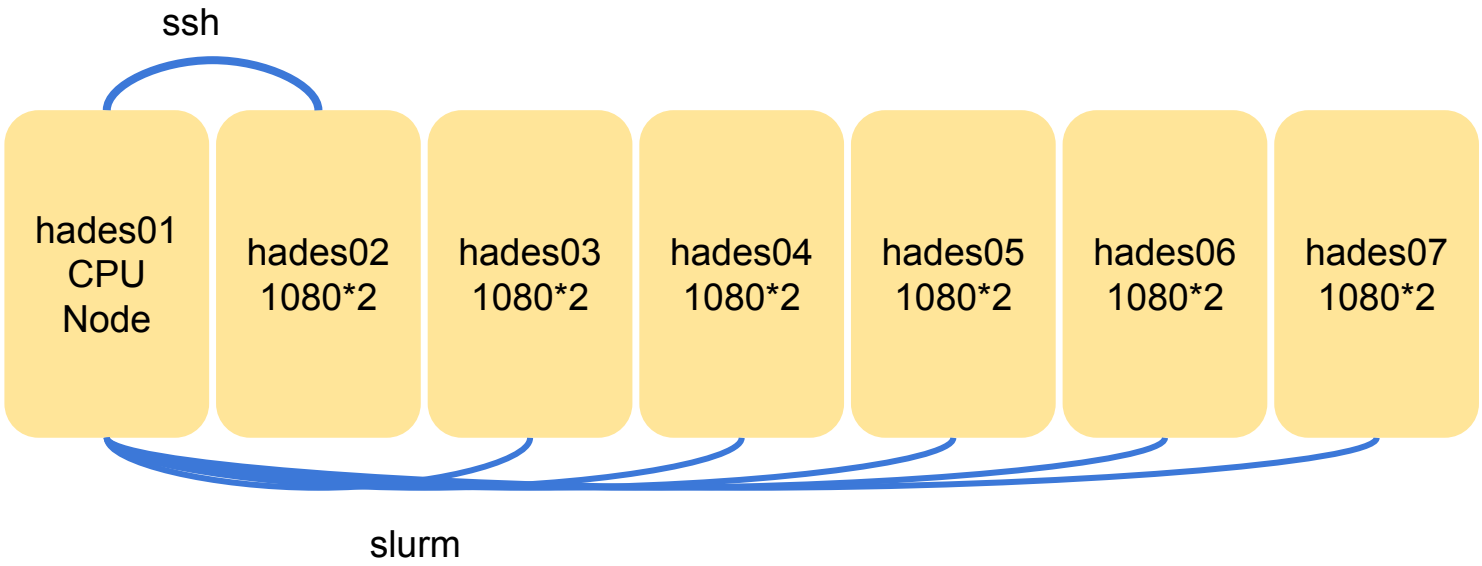
- Platform guide
- Tools
- Assignment

Platform Guide

The GPU Cluster

- Host: hades.cs.nthu.edu.tw
- Account: same as apollo
- Password: same as apollo

The GPU Cluster



Job Scheduler

- SLURM
- Course partition: pp21

```
[pp21t00@hades01 ~]$ sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
pp21*        up       5:00      1  drain hades04
pp21*        up       5:00      4   idle hades[03,05-07]
```

- Limitation
  - 2 gpus
  - 5 minutes

Access Resource

- hades02
  - ssh hades02
  - If you want to specify which GPU to use.
  - `export CUDA_VISIBLE_DEVICES=<gpu id>`
  - eg. `export CUDA_VISIBLE_DEVICES=1`
  - eg. `export CUDA_VISIBLE_DEVICES=0,1`
- hades[03-07]
  - Slurm
  - Access gpus with flag `--gres=gpu:<number of gpu>`
  - eg. `srun -n 1 --gres=gpu:1 ./executable`
  - eg. `srun -n 1 --gres=gpu:2 ./executable`
  - `Two GPUs will be executed on the same node.`

Compile & run

- Compiler nvcc
  - `nvcc [options] <inputfile>`
  - eg. `nvcc cuda_code.cu -o cuda_executable`
- Run
  - Refer to the previous slide

Practice

- In this practice, you can try to run the **`deviceQuery`** on
  - hades02
  - scheduler
- Compile
  - `cp -r /home/pp21/share/lab3/deviceQuery $HOME`
  - `cd $HOME/deviceQuery`
  - `nvcc deviceQuery.cpp -o deviceQuery`
- Run it on
  - hades02
  - scheduler
- How many CUDA cores on GTX1080 ?

Tools

nvidia-smi

- NVIDIA System Management Interface program
- You can query details about
  - gpu type
  - gpu utilization
  - memory usage
  - temperature
  - clock rate
  - ...

nvidia-smi example

```
# michael1017 @ hades02 in ~ [15:08:34]
$ nvidia-smi
Thu Nov 12 15:08:36 2020
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 450.57       Driver Version: 450.57       CUDA Version: 11.0     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|                               |                      |               MIG M. |
|===============================+======================+======================|
|   0  GeForce GTX 1080    On   | 00000000:4B:00.0 Off |                  N/A |
|  0%   37C    P8     7W / 200W |      1MiB /  8119MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+
|   1  GeForce GTX 1080    On   | 00000000:4D:00.0 Off |                  N/A |
|  0%   44C    P8    14W / 200W |      1MiB /  8117MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
```

cuda-memcheck

- This tool checks memory errors of your program, and it also reports hardware exceptions encountered by the GPU. These errors may not cause program to crash, but they could result in unexpected program behavior and memory misusage.
- Error types
  - cuda-memcheck

cuda-memcheck

```
cudaFree(device_t);
cudaFree(device_t); // free an address twice, error
```

```
[mewtwo@hades02 HW4_cuda_sobel]$ cuda-memcheck ./sobel input/candy.bmp out.bmp
========= CUDA-MEMCHECK
========= Program hit cudaErrorInvalidDevicePointer (error 17) due to "invalid device pointer" on CUDA API call to cudaFre
e.
=========     Saved host backtrace up to driver entry point at error
=========     Host Frame:/usr/lib64/nvidia/libcuda.so.1 [0x32f6a3]
=========     Host Frame:./sobel [0x454c0]
=========     Host Frame:./sobel [0x356f]
=========     Host Frame:/usr/lib64/libc.so.6 (__libc_start_main + 0xf5) [0x21b35]
=========     Host Frame:./sobel [0x36ff]
=========
========= ERROR SUMMARY: 1 error
```

cuda-gdb

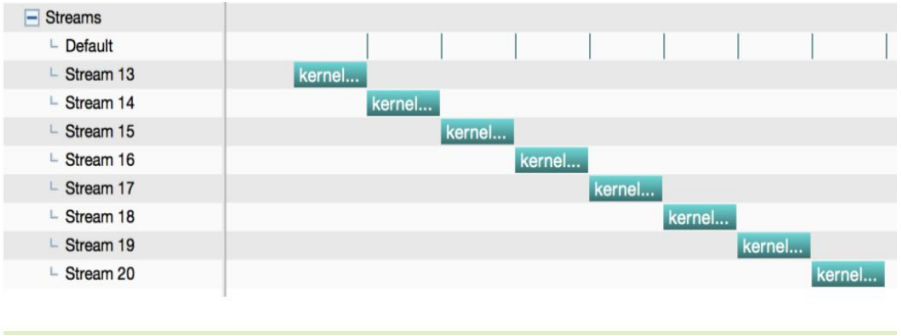
- cuda-gdb tutorial

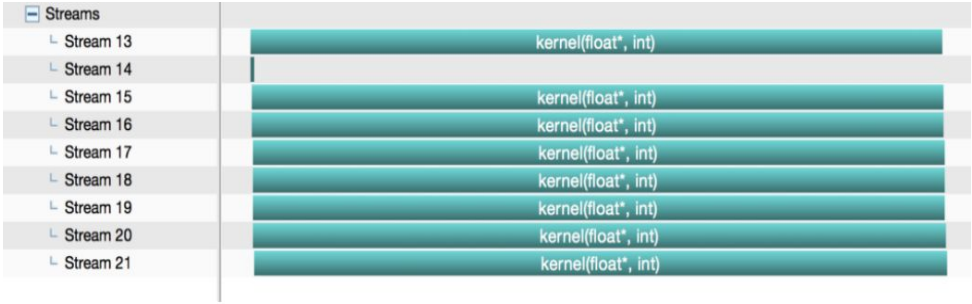
nvprof

- A CUDA profiler provides feedback to optimize CUDA programs
  - `nvprof ./lab3 in.png out.png`
  - `-o <FILE>` to save result to a file
  - `-i <FILE>` to read result from a file

nvvp

- [nvvp-tutorial]
- GUI version of nvprof
- Useful for the stream optimization
  - Timeline



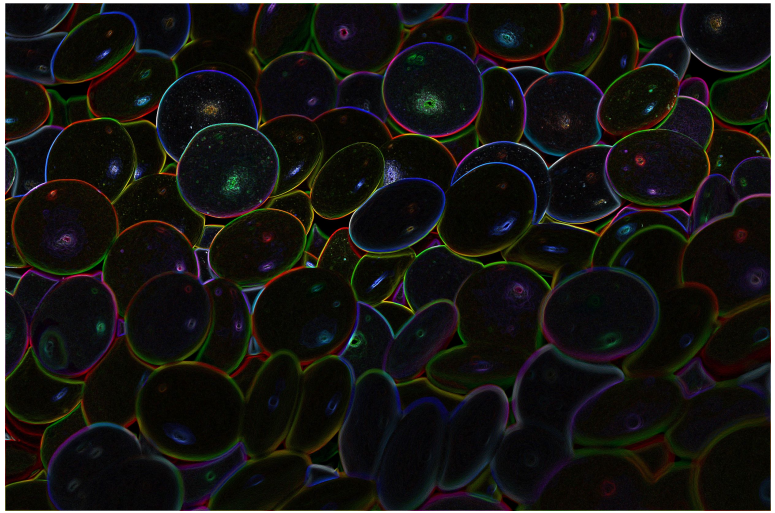


nvvp is useful for checking the concurrency of stream

Lab3 Assignment

Problem Description

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



Sobel Operator

- Used in image processing and computer vision, particularly within edge detection algorithms.
- Uses two 3x3 kernels gx, gy which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical.

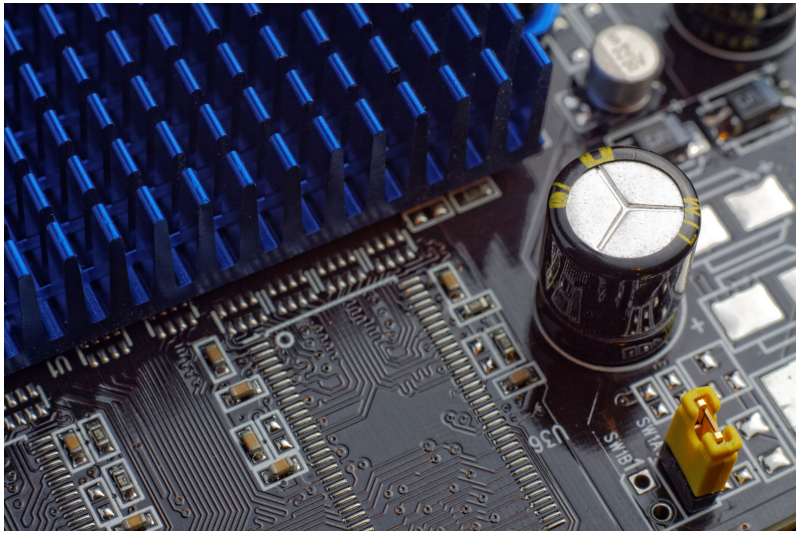
5x5 Variation

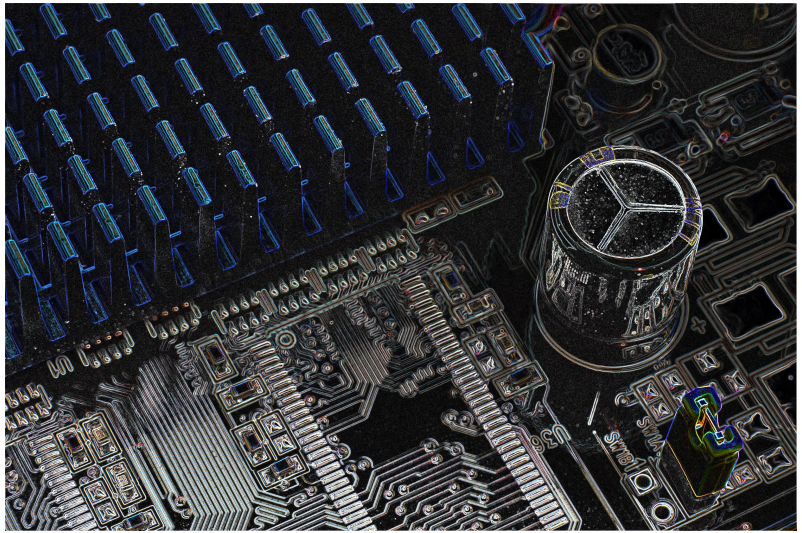
- We use this kernel instead of the 3x3 one in this lab

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

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

Sample Result





Preparation

- TA provides CPU version, Makefile, and hint
- File located at `/home/pp21/share/lab3`
- Please do not copy the testcases.
- `lab3.cu` is cpu version (you need to rewrite it with cuda!)
- You can follow hints to write

How to run

- hades02
  - `./lab3 <input> <output>`
  - `CUDA_VISIBLE_DEVICES=0 ./lab3 <input> <output>`
- hades[03-07]
  - `srun -n 1 ./lab3 <input> <output>`
  - `srun -n 1 --gres=gpu:1 ./lab3 <input> <output>`
- Compare your result with the answer
  - `png-diff <output image> <answer image>`

Hints

- 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

Submission

- judge will execute your code with single process, single GPU
- submit your code and Makefile (optional) to eeclass before 11/18 23:59
- use lab3-judge