Erosion and Dilation GPU

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Subject

Two common morphology operators:

- Dilation
- Erosion

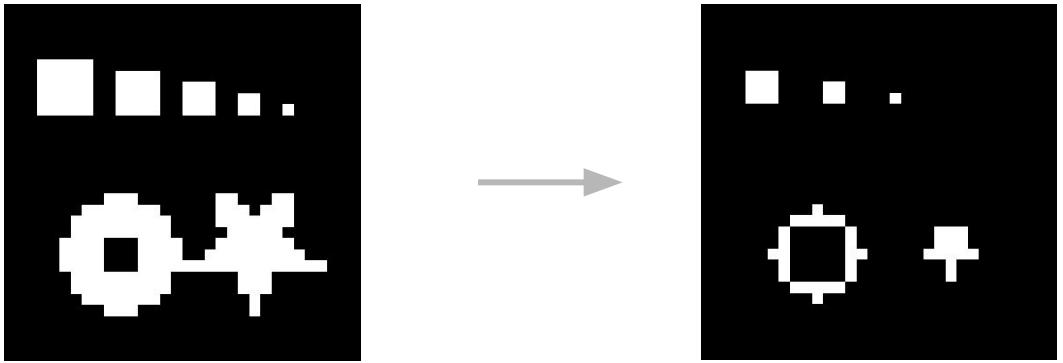
GPU programming language used:

- CUDA

Erosion

$$\varepsilon_B(X) = \{ x \mid B_x \subset X \}$$

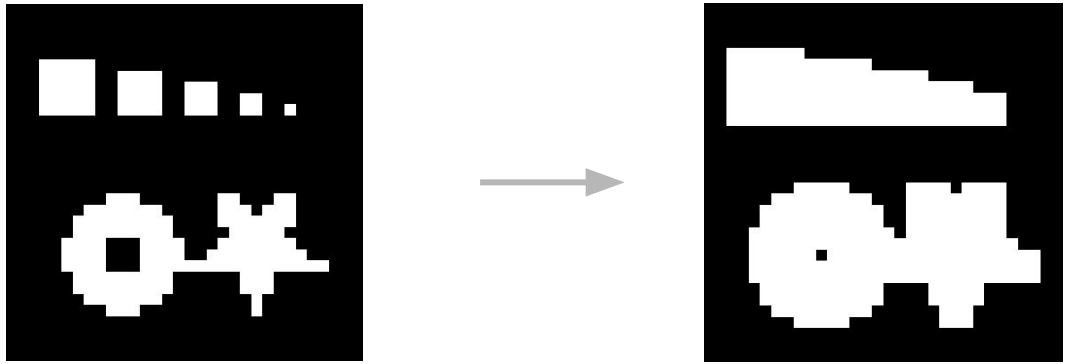
X = image
B = structuring element
x = pixel of image



Dilation

$$\delta_B(X) = \{ x \mid B_x \cap X \neq \varnothing \}$$

X = image
B = structuring element
x = pixel of image



Cuda

- 2007
- NVIDIA
- GPU programming language
- C, C++, Fortran

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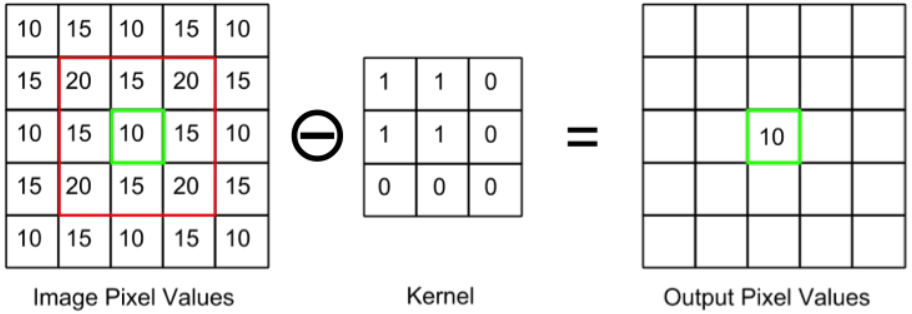
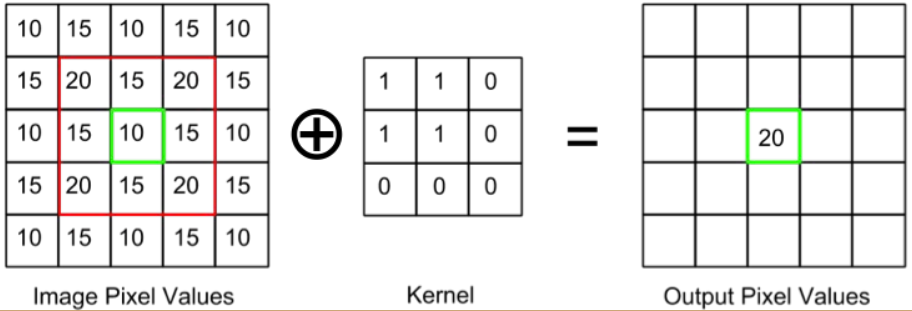
Algorithm

- Based on the convolution algorithm but non-linear



Erosion

Select minimum value



Dilation

Select maximum value

CPU version

- Iterate through the image
- For each pixel:
  - Iterate on the kernel
- Not multithreaded nor vectorized

CPU vectorized version

- Same algorithm as CPU version
- Compiled with flags :
  - `-pthread -m64 -march=native -fopt-info-vec-optimized -O3`
- Most of the loops are vectorized

GPU version

- Addition of padding to the image
- Each pixel is computed in parallel
- Reduced checks for bounds

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Technical Point

- `Erosion<<<numBlocks, threadsPerBlock>>>(...);`
  - `threadsPerBlock: dim3(32, 32)`
  - `numBlocks: dim3(width / 32, height / 32)`

- Std::chrono used to measure execution time

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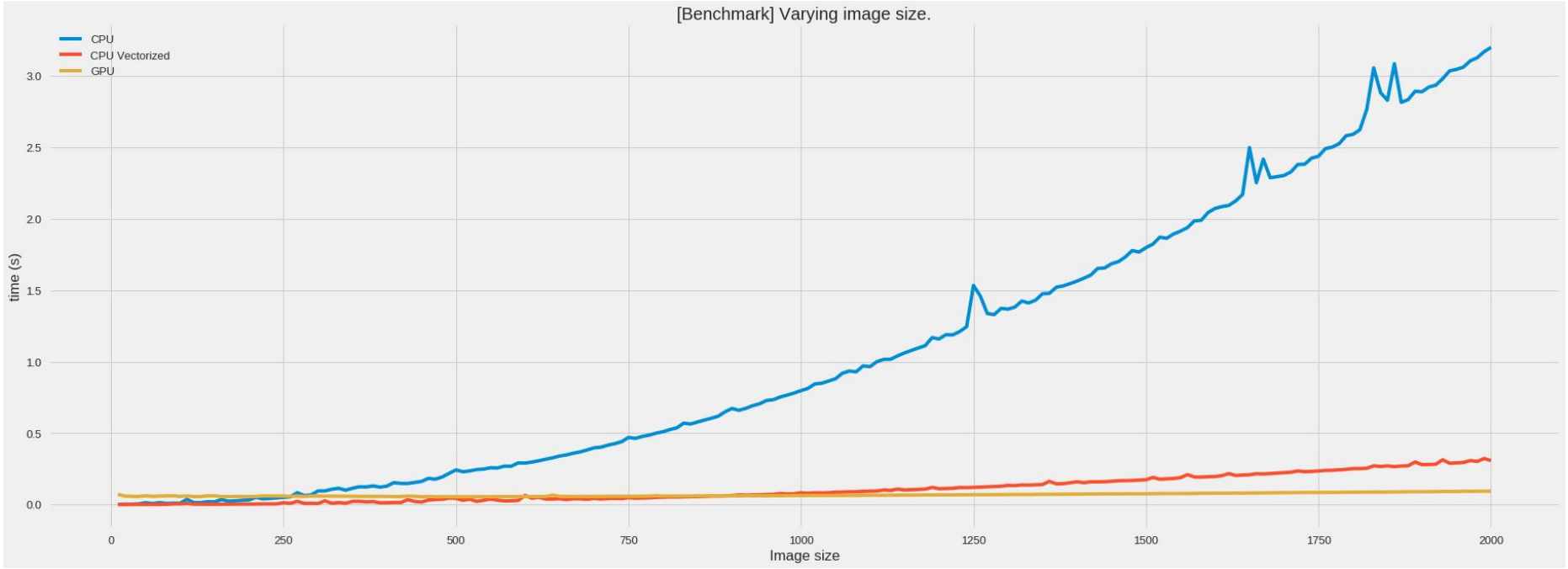
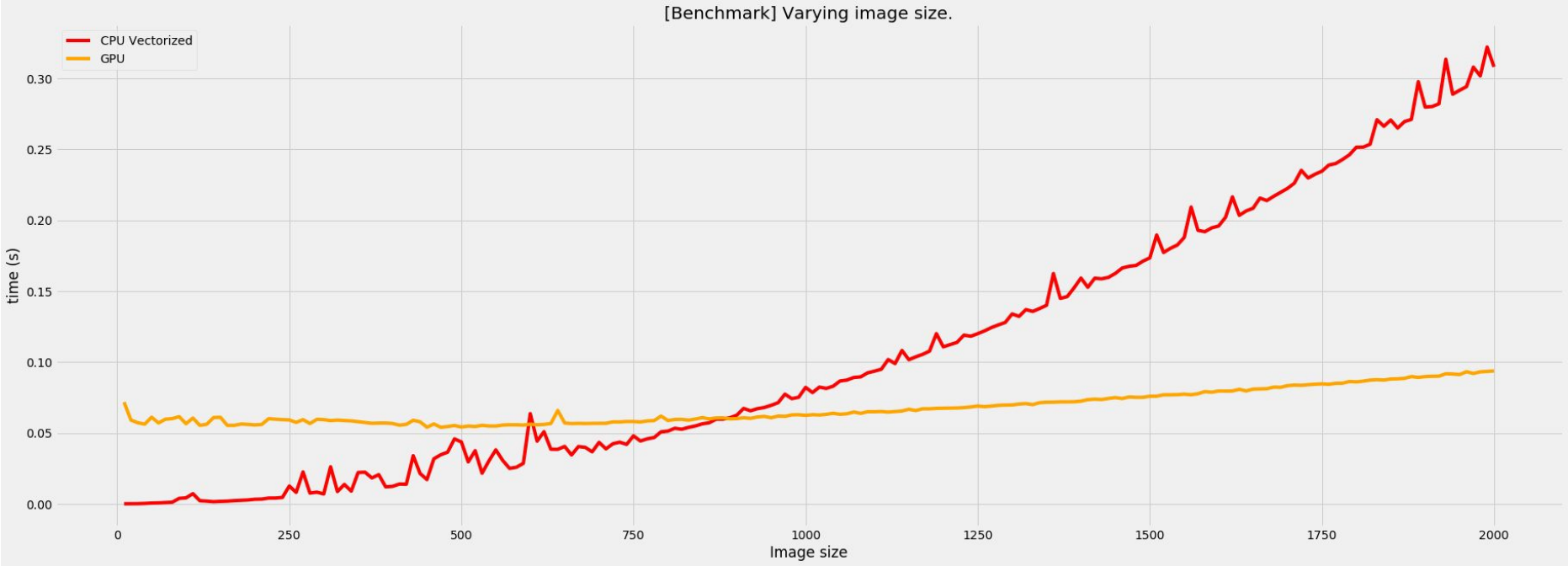
Benchmark



- GPU and vectorized CPU outperform the naive version of CPU

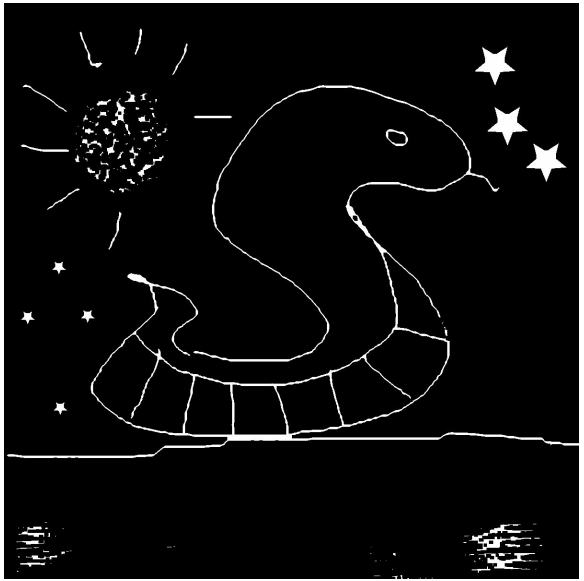
Benchmark

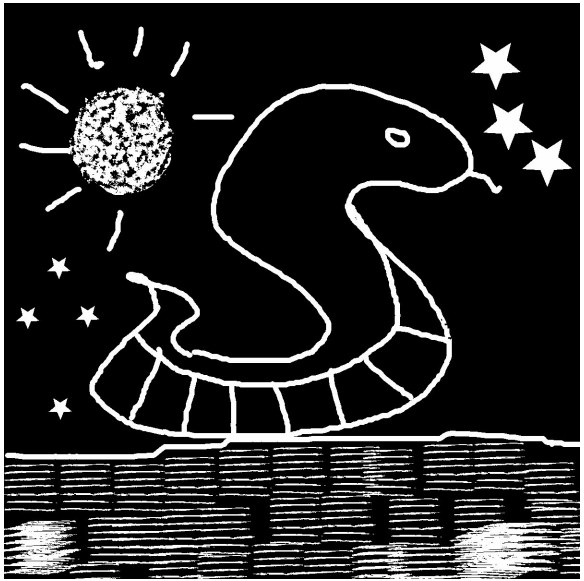


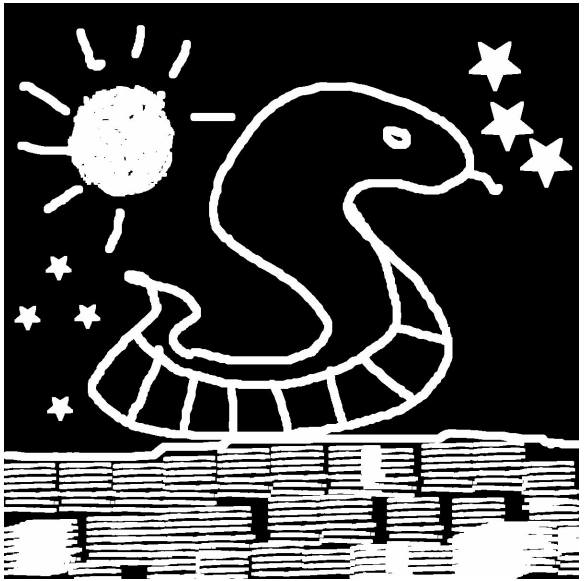
- GPU outperforms with the exception at rates lower than 900*900 image size

Demo

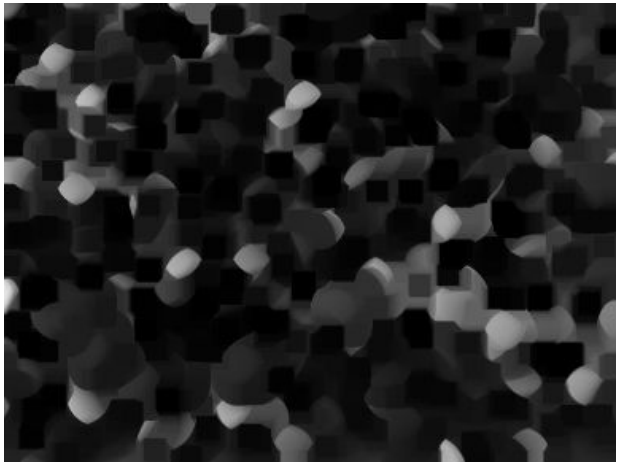
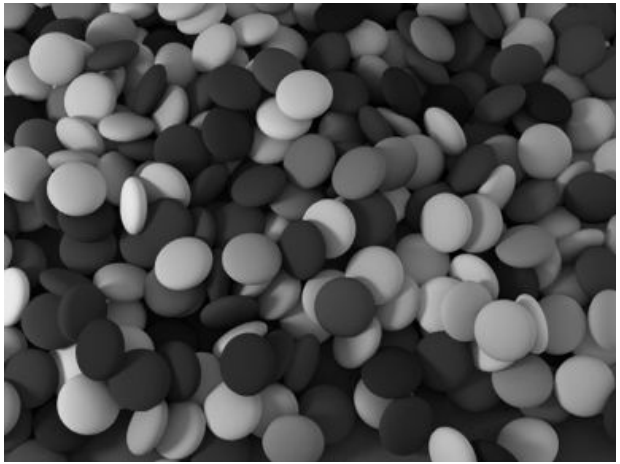
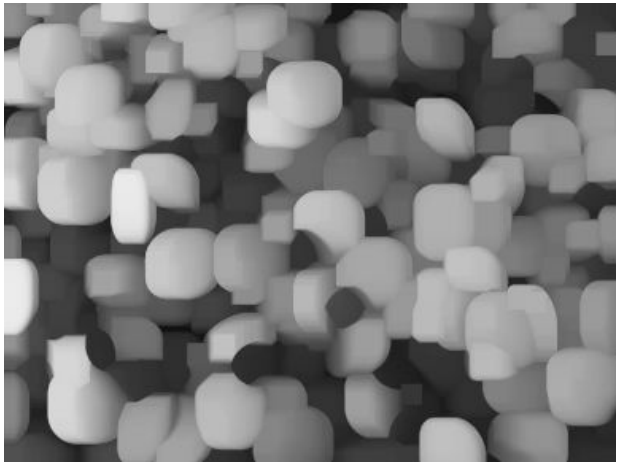
Results







Results

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Conclusion

- Learn CUDA
- GPU version faster depending on image size

Any Questions?