

# Image Blur

## Questions

1. How many floating-point operations are being performed in your color conversion kernel? EXPLAIN.

The kernel performs  $(2 * \text{BLUR\_SIZE} + 1)^2 + 3$  floating-point operations: One float assignment for `pixVal`,  $(2 * \text{BLUR\_SIZE} + 1)^2$  floating-point operations for the nested for loop, and two float assignments for the division and cast at the end of the function.

2. How many global memory reads are being performed by your kernel? EXPLAIN.

The kernel performs  $(2 * \text{BLUR\_SIZE} + 1)^2$  global memory reads in the nested for loop every time we call for the input image data.

3. How many global memory writes are being performed by your kernel? EXPLAIN.

The kernel performs one global memory write for each thread at the end of the function as we write the blurred pixel value to the output image.

4. Describe what possible optimizations could be implemented to your kernel to achieve a performance speedup.

Once again, we can use block sizes that are a multiple of the warp size (32) and use shared memory to reduce the number of global memory reads and writes especially in the nested for loop where we are averaging the pixel values.

```
[junseo@r40a-09.sif bin]$ ./auto_tests.sh
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.34075 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.089653 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 0.705169 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 0.290896 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 1.56495 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.294148 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.210822 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 0.70432 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 0.955755 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 2.50453 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.223451 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.161535 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 0.73628 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 0.474937 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 1.75567 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.333087 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.109002 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 0.696666 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 0.388028 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 1.66858 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.385519 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.581837 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 2.15742 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 2.45711 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 5.74582 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.348169 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.687161 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 2.32875 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 2.77776 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 6.28386 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.522066 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 1.061 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 4.04886 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 4.20752 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 9.99779 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.395571 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 1.02 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 4.01037 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 4.21944 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 9.78794 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.466729 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.598169 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 2.16709 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 2.52398 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 5.9007 ms
The solution is correct
[TIME] [GPU] [Doing GPU memory allocation] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 74-79] Elapsed time: 0.386005 ms
[TIME] [Copy] [Copying data to the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 81-85] Elapsed time: 0.251704 ms
[TIME] [Compute] [Doing the computation on the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 88-97] Elapsed time: 1.06827 ms
[TIME] [Copy] [Copying data from the GPU] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 100-104] Elapsed time: 1.36137 ms
[TIME] [GPU] [Doing GPU Computation (memory + compute)] [/home/warehouse/junseo/cuda-code-repo-joonsuuh/Module3/ImageBlur/solution.cu: 72-106] Elapsed time: 3.252 ms
The solution is correct
```

Figure 1: ImageBlur\_Solution output