

Box Blur-Filter with GL Interoperability

1 Overview

1.1 Location \$(AMDAPPSDKSAMPLESROOT)\samples\opencl\cl\app

1.2 How to Run See the *Getting Started* guide for how to build samples. You first must compile the sample.

Use the command line to change to the directory where the executable is located. The pre-compiled sample executable is at \$(AMDAPPSDKSAMPLESROOT)\samples\opencl\bin\x86\ for 32-bit builds, and \$(AMDAPPSDKSAMPLESROOT)\samples\opencl\bin\x86_64\ for 64-bit builds.

Type the following command(s).

1. `BoxFilterGL`
This applies a box blur filter on the input image.
2. `BoxFilterGL -h`
This prints the help file.

1.3 Command Line Options Table 1 lists, and briefly describes, the command line options.

Table 1 Command Line Options

Short Form	Long Form	Description
-h	--help	Shows all command options and their respective meaning.
	--device	Devices on which the program is to be run. Acceptable values are <code>cpu</code> or <code>gpu</code> .
-q	--quiet	Quiet mode. Suppresses all text output.
-e	--verify	Verify results against reference implementation.
-t	--timing	Print timing.
	--dump	Dump binary image for all devices.
	--load	Load binary image and execute on device.
	--flags	Specify compiler flags to build the kernel.
-p	--platformId	Select platformId to be used (0 to N-1, where N is the number of available platforms).
-d	--deviceId	Select deviceId to be used (0 to N-1, where N is the number of available devices).
-v	--version	AMD APP SDK version string.
-i	--iterations	Number of iterations for kernel execution.
-x	--width	Filter width.
-sep	--separable	Flag for separable version.
-sat	--sat	Flag for SAT version.

2 Introduction

Box filtering, also known as average or mean filtering, is a method of reducing the intensity variation between pixels in an image, and is a commonly used technique to reduce noise.

3 Implementation Details

Two versions of Box filter have been implemented –

1. BoxFilter separable
2. BoxFilter with precomputed summed area tables

3.1 BoxFilter Separable

Filtering an M-by-N image with a P-by-Q filter kernel requires roughly $MNPQ$ multiplies and adds.

If the kernel is separable, you can filter in two steps. The first step requires about MNP multiplies and adds. The second requires about MNQ multiplies and adds, for a total of $MN(P + Q)$.

Implementation consists of applying the filter horizontally, then vertically.

Figure 1 compares the performance between a naïve and a separable BoxFilter.

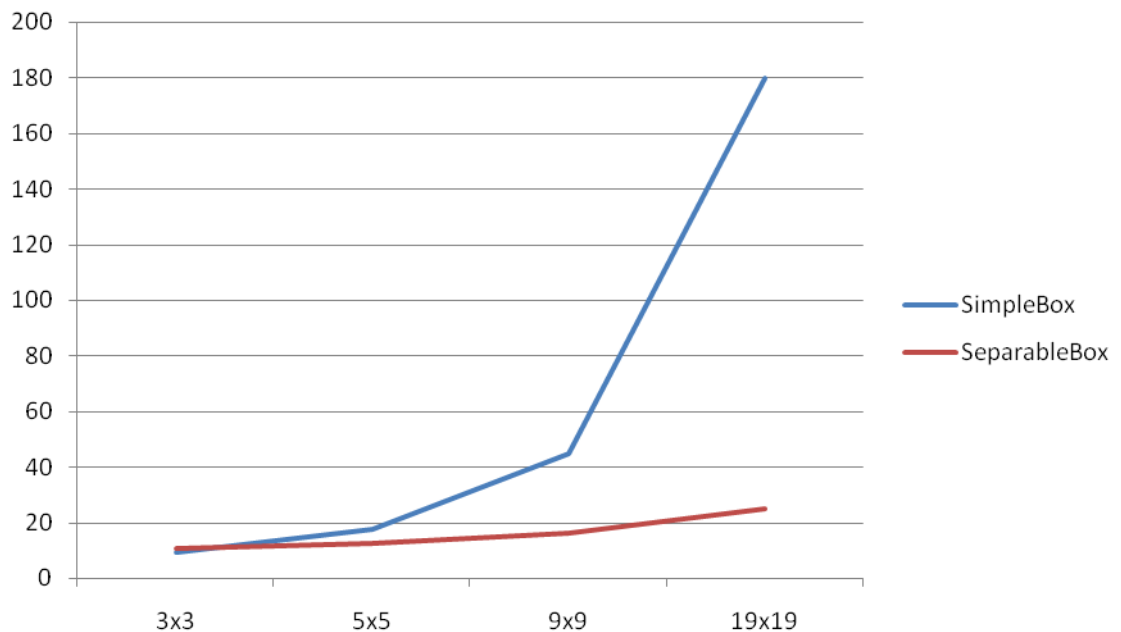


Figure 1 Time Taken (in msec) vs Filter Size on an ATI Radeon™ HD 4870 GPU

Loop unrolling optimization results in approximately 10% to 20% improvement, depending on the specified filter width. This means approximately 180 fps for a 1024 x 1024 image (filter size 9x9) on an ATI Radeon™ HD 5770 with GL interoperability.

The flag for using hardware local memory in the horizontal pass of the separable filter has been commented out due to performance decrease.

3.2 BoxFilter with SAT

Summed-area tables (SATs) were introduced by Crow (see reference [1]) to accelerate texture filtering. Each element in a SAT is the sum of all texture elements in the rectangle above and to the left of the element (see Figure 2).

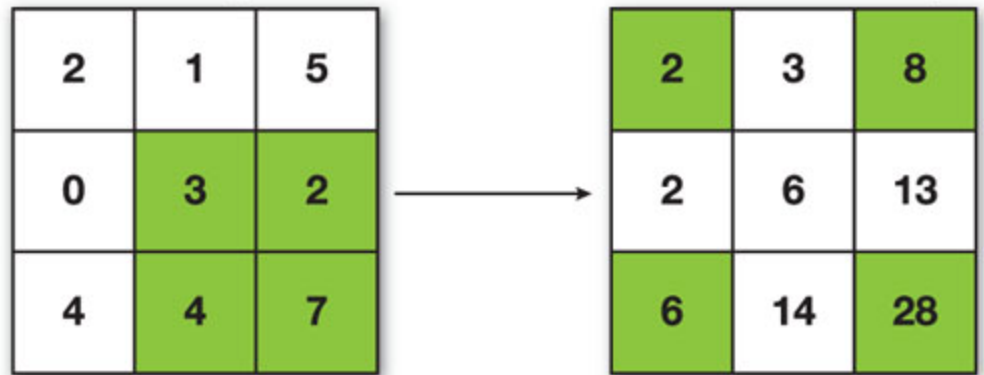


Figure 2 Sample Data and Corresponding SAT

The sum of any rectangular region then can be determined in constant time using:

$$s = t[x_{\max}, y_{\max}] - t[x_{\max}, y_{\min}] - t[x_{\min}, y_{\max}] + t[x_{\min}, y_{\min}]$$

It is easy to compute the average over this region by dividing by the number of pixels in the region.

SATs let us sample arbitrary rectangular regions, which is sufficient for applying a box filter of any size on an image.

3.3 Computing SAT

Computing a SAT is done in two passes.

1. Horizontal pass – the prefix sum is applied on each row separately.
2. Vertical pass – the prefix sum is applied on column separately.

After computing a SAT, a final BoxFilter kernel requires fetching only four values from a global buffer to compute the final filtered image.

This technique is very fast for interactive applications because, after applying the precomputation, it is possible to change the filter size immediately without degrading performance. For example, a 1024 x 1024 image gives us about 250 fps using GL interoperability on the ATI Radeon™ HD 5770, irrespective of box filter size.

Note that the value of the sums (and, thus, the dynamic range) can become very large; the table entries require extended precision. The number of bits of precision needed per component is calculated using:

$$P_s = \log_2(w) + \log_2(h) + P_i$$

where: w and h are the width and height, respectively, of the input image.

P_s is the precision required to hold values in the SAT.

P_i is the number of bits of precision of the input.

Given this, a 256 x 256 texture with eight-bit components requires a SAT with 24 bits of storage per component. Thus, we use 32-bit per pixel image data ($12 + 12 + 8 = 32$) for the calculation of the SAT. This can maximally process a 4096 x 4096 image.

4 References

1. Crow, Franklin (1984). "Summed-area tables for texture mapping". *SIGGRAPH '84: Proceedings of the 11th annual conference on Computer graphics and interactive techniques*, pp. 207–212.

Contact

Advanced Micro Devices, Inc.
One AMD Place
P.O. Box 3453
Sunnyvale, CA, 94088-3453
Phone: +1.408.749.4000

For AMD Accelerated Parallel Processing:
URL: developer.amd.com/appsdk
Developing: developer.amd.com/
Support: developer.amd.com/appsdksupport
Forum: developer.amd.com/openclforum



The contents of this document are provided in connection with Advanced Micro Devices, Inc. ("AMD") products. AMD makes no representations or warranties with respect to the accuracy or completeness of the contents of this publication and reserves the right to make changes to specifications and product descriptions at any time without notice. The information contained herein may be of a preliminary or advance nature and is subject to change without notice. No license, whether express, implied, arising by estoppel or otherwise, to any intellectual property rights is granted by this publication. Except as set forth in AMD's Standard Terms and Conditions of Sale, AMD assumes no liability whatsoever, and disclaims any express or implied warranty, relating to its products including, but not limited to, the implied warranty of merchantability, fitness for a particular purpose, or infringement of any intellectual property right.

AMD's products are not designed, intended, authorized or warranted for use as components in systems intended for surgical implant into the body, or in other applications intended to support or sustain life, or in any other application in which the failure of AMD's product could create a situation where personal injury, death, or severe property or environmental damage may occur. AMD reserves the right to discontinue or make changes to its products at any time without notice.

Copyright and Trademarks

© 2011 Advanced Micro Devices, Inc. All rights reserved. AMD, the AMD Arrow logo, ATI, the ATI logo, Radeon, FireStream, and combinations thereof are trademarks of Advanced Micro Devices, Inc. OpenCL and the OpenCL logo are trademarks of Apple Inc. used by permission by Khronos. Other names are for informational purposes only and may be trademarks of their respective owners.
