AMD **Accelerated**
Parallel Processing
TECHNOLOGY

SAMPLE

Simple Convolution

1 Overview

1.1 Location

$<*AMDAPPSDKSamplesInstallPath*>\samples\opencl\cl\1.x

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 precompiled sample executable is at
$<*AMDAPPSDKSamplesInstallPath*>\samples\opencl\bin\x86\ for 32-bit builds, and
$<*AMDAPPSDKSamplesInstallPath*>\samples\opencl\bin\x86_64\ for 64-bit builds.

Type the following command(s).

1. `SimpleConvolution`
   Performs convolution of a 64x64 image with a blur mask of 3x3.
2. `SimpleConvolution -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 cpu or gpu.
-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.
-x	--width	Width of the input matrix.
-y	--height	Height of the input matrix.

Short Form	Long Form	Description
`-m`	`--masksize`	Dimension of convolution filter.
`-i`	`--iterations`	Number of iterations for kernel execution.
`-l`	`--localSize`	Work-group Size.

2 Introduction

Convolution or image filtering is widely used in Image Processing applications such as blur, smooth effects, or edge detection. The sample shows the naive implementation of convolution. The sample supports only 3X3 and 5X5 Sobel Filter.

The convolution or filtering operation can be implemented in two ways. One is a separable convolution, meaning that the filtering or convolution is done in two separate passes. The other is a non-separable convolution, where convolution is done in one pass. The advantage of separable filter over the non-separable filter is that it reduces the number of arithmetic operation. For example, naïve convolution with 2-D square filter of size (m x m) requires m^2 number of mad (multiplication and addition) operations for each pixel, whereas separable version of same filter reduces the number to 2m.

OpenCL implementation of fixed sized separable convolution with 2 passes could be done in several ways. In this sample, we demonstrate the approach of using 2 separate kernels for each of the passes. A more advanced version of separable convolution using a single kernel for both the passes is demonstrated in the AdvancedConvolution SDK sample.

3 Implementation Details

A convolution filter is just a scalar product of the filter weights with the input pixels within a window surrounding each of the output pixels.

This sample includes two kernels:

- **Non-separable Filter – [One pass: a naïve implementation]:**
  Non-separable filter is a one pass convolution operation. This kernel implements 2D convolution on device global memory. In non-separable convolution, each pixel of the output image is calculated by fetching raw pixels, performing a scalar product of each pixel with pre-defined filter coefficients.
- **Separable Filter - [Two passes]:**
  This kernel implements a two pass convolution of a 2D separable filter. It uses 2 separate kernels; one is horizontal filter (or row-wise filter) and second is vertical filter (or column-wise filter). The first pass applies a one-dimensional horizontal filter to the entire image row of pixels, does additional work of transposing the output and store result column-wise rather than row-wise. In second pass, although it works along the row as well, actually it does vertical filtering, since the frame has already been transposed in first pass and finally it transposes the output so that resulting image is restored in its original orientation.

4 References

1. http://en.wikipedia.org/wiki/Convolution
2. http://en.wikipedia.org/wiki/Separable_filter
3. http://blogs.mathworks.com/steve/2006/10/04/separable-convolution/

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