Advanced Video Motion Estimation Tutorial

Sample User's Guide

OpenCL™ Code Builder - Samples

Contents

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About the Advanced Motion Estimation Tutorial

The Advanced Video Motion Estimation (VME) tutorial provides step-by-step guidelines on using the Intel's motion estimation extensions for the OpenCL™ standard. The advanced motion estimation extension includes a set of host-callable functions for frame-based Video Motion Estimation.

The motion estimation extension depends on the OpenCL 1.2 notion of the built-in kernels, on basic `cl_intel_motion_estimation` extension, and on the Intel's "accelerator" extension, which provides an abstraction for the specific hardware-accelerated capabilities.

Notice that to simplify the host logic, the tutorial code example accepts raw YUV files in YV12 only. Refer to the http://www.fourcc.org/yuv.php#YV12 for details on the YV12 format.

Introduction

Motion estimation is the process of determining the motion vectors that describe the transformation from one 2D image to another, usually from adjacent frames in a video sequence. The motion estimation functions, considered in this article, accept full-frame single-channel (luma) images as input, perform a motion search operation, and return a motion vector field as output.

The introduced VME functionality exposes part of the hardware acceleration pipeline for video acceleration. In contrast to basic `cl_intel_motion_estimation` extension, advanced extension `cl_intel_advanced_motion_estimation` provides additional control over motion vectors estimation process. Multiple kernel input arguments give possibility of fine VME algorithm tuning to reach the best results depending on input video stream characteristics. The new extension additionally provides skip-check functionality required by novel video coding algorithms.

For more details on the VME and associated extensions APIs, refer to the technical article on the Advanced VME at http://software.intel.com/en-us/articles/intro-to-advanced-motion-estimation-extension-for-opencl.

Motivation

Motion vectors are the key element in the video compression algorithms. Motion vectors are also useful for several applications. For example, when generating "slow motion" effects, motion vectors can provide the basis to generate intermediate frames for frame rate (up) conversion. Another example is increasing the original frame rate of the digitized film (24 fps) to match the TV rate.

Motion vectors are also useful for image stabilization: the motion vectors in the entire frame can be averaged to produce a "global" motion vector, which can serve as an approximation to a real video camera motion.

Skip-check functionality helps to determine Macro Blocks (MB) which can be omitted in encoding process because of insignificant change from frame to frame. It results in significant computation and bandwidth reduction.

Accelerator and Motion Estimation Extensions

The Advanced Motion Estimation Extension consists of the new OpenCL built-in kernel (see OpenCL 1.2 specification section 5.6.1) which performs motion estimation, as well as the accelerator object, which represent the state of the underlying acceleration engine. The kernel is queued for execution from the host using the standard ND-range mechanism.

Both `cl_intel_accelerator` and `cl_intel_advanced_motion_estimation` extensions should be listed in the `CL_DEVICE_EXTENSIONS` string (see OpenCL 1.2 specification section Table 4.3) for the Intel Processor Graphics device. If not, update the Intel® Graphics Driver via the Intel® Driver Update Utility.

Hardware Considerations

The goal of the sample is to demonstrate hardware-accelerated VME functionality that Intel HD Graphics device offers. Thus, to run the sample, a 3rd Generation Intel® Core™ processor (and higher) or an Intel® Atom™ processor with the Intel Processor Graphics is required.

Implementation Details

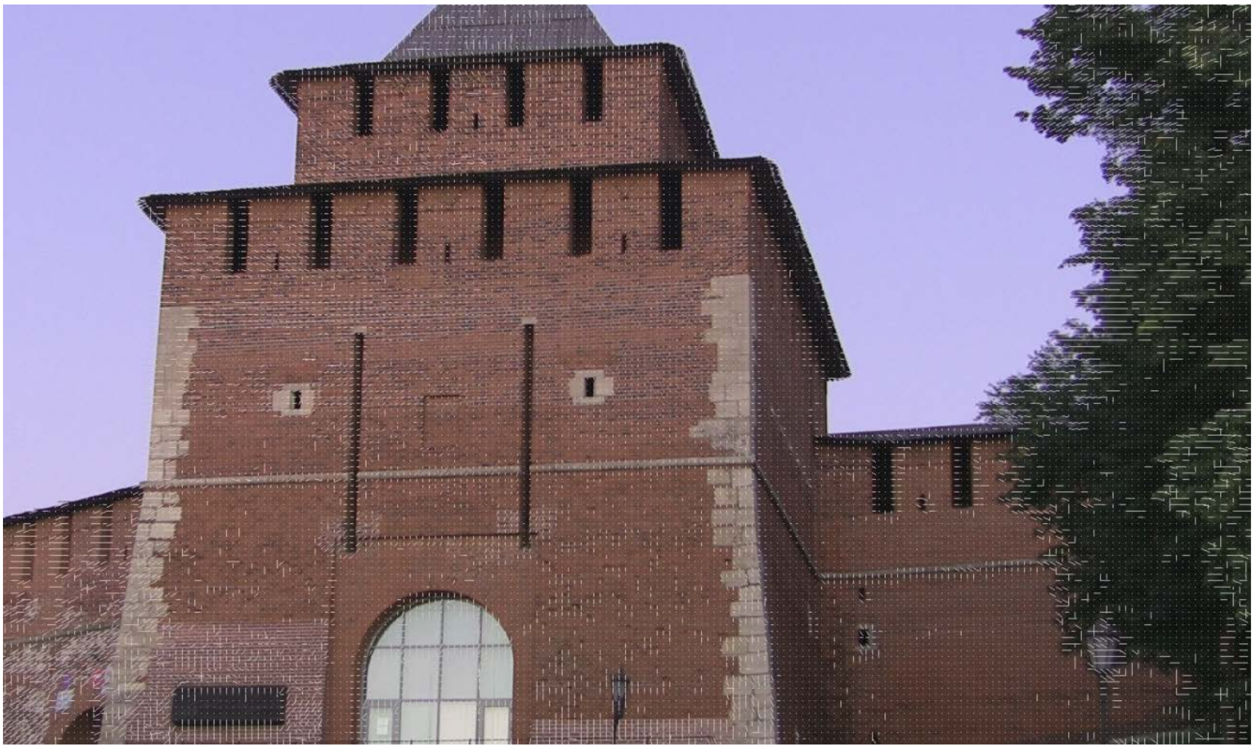
The tutorial utilizes the following APIs:

- `clGetExtensionFunctionAddressForPlatform`
- `clCreateAcceleratorINTEL`
- `clReleaseAcceleratorINTEL`
- `clEnqueueNDRangeKernel`
- `clCreateProgramWithBuiltInKernels`

Example Results

The pictures below show two frames (reference and source) and computed motion vectors overlaid on the second frame. Specifically, the vectors are rendered as the strokes of the appropriate magnitude. So they point to the new (actually best-matched) pixel block positions.

Notice the radial pattern of the motion vectors, which is due to the nature of the transformation between frames (zoom in addition to the camera movement).



Refer to the technical article for some performance considerations related to the Advanced VME at http://software.intel.com/en-us/articles/intro-to-advanced-motion-estimation-extension-for-opencl.

Controlling the Sample

The sample executable is a console application. Notice that the sample-specific parameters have default values, so you can run the sample binary without specifying any command-line options.

The following command-line arguments are available:

Option	**Description**
`-h, --help`	Show this help text and exit.
`--input <string>`	Input video sequence filename - YUV file (YV12 format). Default input file is `1920x1080_5frames.yuv`
`--output <string>`	Output video sequence with overlaid motion vectors filename - YUV file (YV12 format). Default name for the output file is `output.yuv`.
`--nobmp`	Disable output frames to the sequence of BMP files in addition to the YUV file. By default the output is on.
`--width <int>`	Set frame width for the input file. Default value is 1920.
`--height <int>`	Set frame height for the input file. Default value is 1080.
`--block <string>`	Set VME macro block type. Can be 4x4, 8x8 and 16x16. Default value is 8x8.
`--penalty <string>`	Set cost penalty type depending on movement characteristics. Can be none, low, normal and high. Default value is high.
`--precision <string>`	Set cost precision in pixels. Can be quarter, half, full and double. Default value is quarter.

`--predictors <int>`	Set number of predictor motion vectors. Valid values are in range [0,8]. Default value is 8.

By default, the sample output sequence of bitmap files that duplicates the content of the output YUV stream.

References

1. Motion Estimation Extension for OpenCL™ specification at http://www.khronos.org/registry/cl/extensions/intel/cl_intel_motion_estimation.txt
2. Accelerator Extension for OpenCL™ specification at http://www.khronos.org/registry/cl/extensions/intel/cl_intel_accelerator.txt
3. Intro to Motion Estimation Extension for OpenCL™ at http://software.intel.com/en-us/articles/intro-to-motion-estimation-extension-for-opencl
4. Advanced Motion Estimation Extension for OpenCL™ specification at https://www.khronos.org/registry/cl/extensions/intel/cl_intel_advanced_motion_estimation.txt
5. Intro to Advanced Motion Estimation Extension for OpenCL™ at http://software.intel.com/en-us/articles/intro-to-advanced-motion-estimation-extension-for-opencl