PSIVT 2013 tutorial proposal:
OpenCV + CUDA

Interactive tutorial

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Abstract. OpenCV is an open source library focused to implement computer vision algorithms. It is a cross-platform library employed for both commercial and research purposes. OpenCV has the advantage of being compatible with parallel computing libraries such as CUDA, enabling it to handle real-time applications. The aim of this tutorial is to give a general panorama of how to combine both libraries (OpenCV and CUDA) in order to develop real-time computer vision applications through parallel computing using the Graphic Processing Unit.

Motivation and Target audience

Computer vision is a research area in which methods for understanding, analyzing and processing images are developed. Many computer vision algorithms are complex and therefore the computational cost may be expensive. For this reason, it is interesting to use parallelizing techniques to reduce the computational time of the algorithms.

In recent years, one popular technique to decrease the processing time by parallelization is the use of the Graphic Processing Unit (GPU) in general purpose problems. The reduction of time in the algorithm’s execution helps us to be able to perform more experiments, to obtain more results in less time and to perform real-time applications.

The aim of this tutorial is to give a general panorama of how to combine two cutting-edge libraries (OpenCV and CUDA) in order to develop real-time computer vision applications through parallel computing by using the GPU.
Our tutorial is thought for (but not limited to) teachers, researchers and students who work in areas such as: computer vision, image and video processing, or parallel computing, interested in programming computer vision applications in parallel by using the GPU.

The only strong requirement we need to impose to the potential attendees is a basic knowledge of the C/C++ programming language, which is the main language used to write modules in the OpenCV/CUDA libraries.

**Topics to be presented (Outlines)**

1. OpenCV & Cuda (Brief Introduction)
2. Image processing in OpenCV
3. Memory allocation in the GPU
4. Memory passing between OpenCV and CUDA
5. Operation on parallel (GPU management)
   a. Vector/Matrix operations:
      i. Addition
      ii. Addition with reduction primitive techniques
      iii. Multiplication
6. Parallel Image processing:
   a. Images composition
   b. Gradient magnitude
   c. Image filtering
   d. Corner detector
   e. Diffusion image
7. Native Functions of OpenCV that use CUDA (gpu::mat)
8. Parallel Image processing using multiple GPUs: Examples
9. Conclusions: Potential applications

**Tutorial format**

This 4-hour tutorial is divided into:

- A 30 min talk about the features of both libraries (OpenCv and CUDA) and implementation details with examples.
- A 3.5-hour practical session of software module programming in front of
computers with assistance of the instructors.

The practical session will consist in discovering both libraries through simple examples and the development of some small applications that read an image with OpenCV library and manipulate it in parallel with the CUDA library. Those sample applications will allow to understand how to manage the memory of the GPU and how to access and modify an image in parallel. We will explain how both libraries can be used in more complex research applications, such as video tracking, medical image analyzing, video segmentation, among others.

Tutorial and supplementary material can be downloaded from here.

Technical requirements

- From 10 to 15 desktop computers. The number of assistants will be limited to the number of computer times two.
- Each computer must be equipped with:
  - A NVIDIA video card with CUDA support
  - Operating System: Linux, OpenCV and CUDA libraries installed. A day before the tutorial, we would install the necessary software and the examples and demos for the tutorial. Just in case, we would bring a copy of the software.
- Any attendant is free to bring its own laptop equipped with an NVIDIA graphic card. Please the attendant must check here if the laptop’s GPU is CUDA-Enabled.

Background of the instructors

**Francisco Madrigal** is PhD student at CIMAT (Center for Mathematical Research), in Guanajuato, Mexico. He got his Master degree at CIMAT in 2010. His main research topic is Visual Tracking.

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