CUDA-Based Massively Parallel Implementation of Gray-Scale Mathematical Morphology Operations in Java

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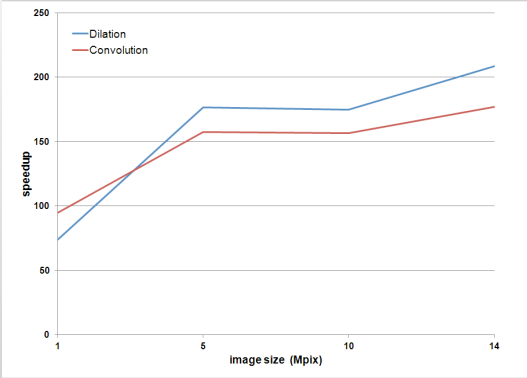
Abstract

Parallelization of image processing algorithms can be achieved either on the Central Processing Unit (CPU) or on the Graphics Processing Unit (GPU) side. High level support of parallelization schemes is still minimally developed in Java, which is a definite disadvantage compared to C++ and C#. The support of GPU parallel image processing in Java is still minimal and depends on custom libraries. The availability of image processing frameworks in Java, such as ImageJ, together with the potential of GPUs to offer high performance at low cost makes it attractive to bridge this gap. On the other hand, the advantages of GPU parallel architecture are penalized by the memory transfer overheads, which make GPU implementation of certain classes of algorithms not useful. In this work we demonstrate a combined Java and CUDA based implementation for the basic morphological operations and spatial convolution. It is demonstrated that the overhead of Java is negligible, which presents a viable option for integration of GPU code into Java programs. The CUDA-enabled GPUs have four types of memory, notably global memory, constant memory, texture memory and shared memory. The results indicate that the most advantageous GPU implementation is by using texture memory. Our results show an advantage of GPU parallelization over sequential implementation on the CPU for both convolutions and mathematical morphology operations. Using 3x3 kernel, on a NVIDIA GeForce GTX 470 platform the speedup of the CUDA processing was ranging from 177 to 208 times for convolution and dilation respectively .

Keywords

Convolution, morphology, dilation



Runtime speedup on NVIDIA GeForce GTX 470 as a function of image size