Evaluating the Performance of Processing Medical Volume Data on Graphics Hardware

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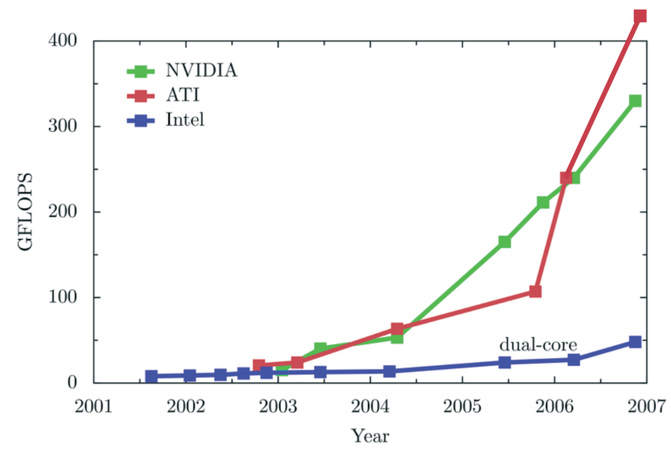
Motivation

Modern graphics hardware (GPU) is often used **only for visualization** tasks in medical applications. Although there has been a lot of research in generalizing the high computational power of standard graphics processors, two **main problems** remain:

- programming the GPU requires **in-depth knowledge** of computer graphics concepts
- the performance gain for single operations is often outweighed by the **additional data transfer**

As the performance gap between GPUs and (multi-core) CPUs continues to grow (see figure), using graphics hardware also for processing tasks is of high interest [1-3]. Thus, we have evaluated the performance for basic medical image processing tasks in order to motivate the **utilization of graphics hardware for computations** in current medical applications. Both single operations and sequences of different complexity have been implemented using **two different frameworks**, our GPU-based system **"Cascada"** and the widely used **"MeVisLab"** [4], and have been tested on typical data sets with commodity PC/graphic hardware systems.

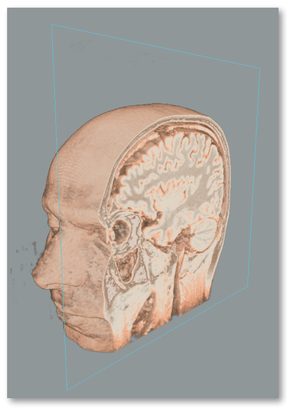


Development of commodity processing units' performance in recent years (Illustration courtesy [1])

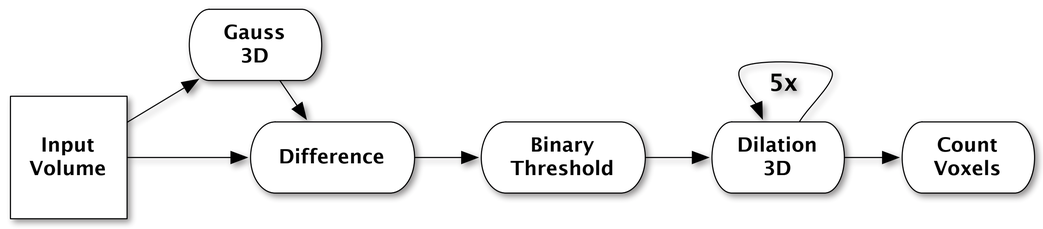
Test setup

- Intel Core2Duo, 2.4 GHz, 2 GB RAM
- Nvidia Geforce 8800 GTS, 640 MB
- Windows XP, with:
  - MeVisLab 1.5.1
  - Cascada 1.0
- Medical data sets of typical size and bit depth:

Abdomen CTA
512 x 512 x 223,

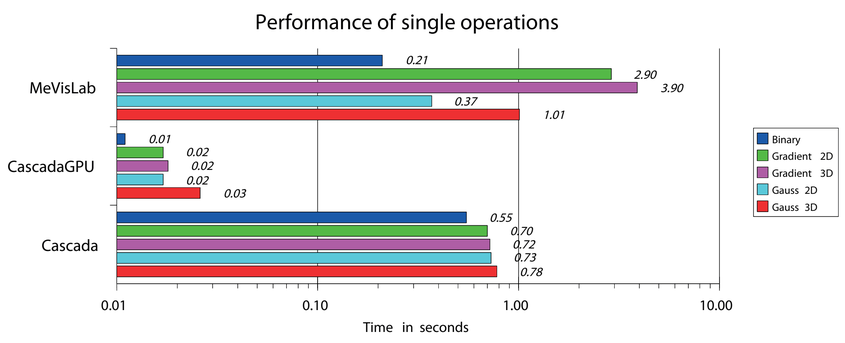


Head MRI
256 x 256 x 256

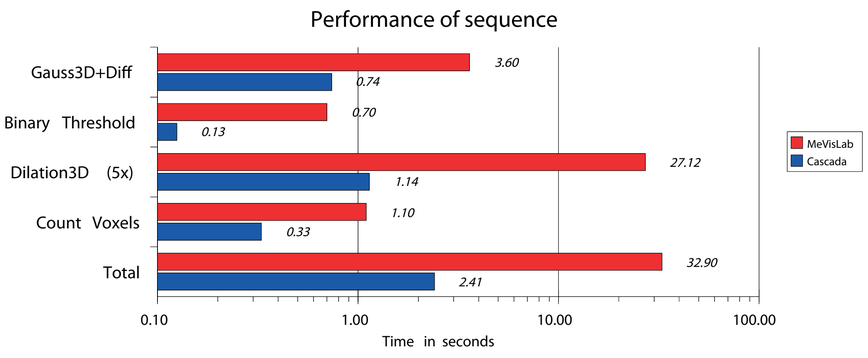


- Example sequence comprised of different processing tasks:
  - independent voxel operations (differencing, thresholding)
  - kernel filter (Gaussian)
  - morphological operations (iterated dilation)
  - volumetry

Results



- GPU-only implementations of common kernels clearly outperform software filter
- GPU algorithms are less sensitive to the amount of data and complexity of kernel operations than software implementations
- However, including the transfer from/to the graphics memory often abolishes the GPU's performance advantage



- Successive computations on the different platforms (both without memory transfer) show better overall performance
- Utilizing the graphics hardware for whole workflows reveals their clear performance superiority

Conclusion

- Clear performance advantage for hardware implementations, if many tasks are executed on GPU
- Also more intricate computations (vesselness filter, watershed transform, etc.) are up to multiple orders of magnitude faster
- With the processed data in graphics memory, (intermediate) results can be visualized directly with negligible performance overhead
- Our approach for GPU programming in "Cascada" is more application-oriented than current low-level APIs such as CUDA or CTM
- Further evaluation of more complex operations and the influence of different optimization strategies towards a classification of algorithms for load balancing during run-time etc.

References

[1] Owens JD, Luebke D, Govindaraju N, Harris M, Krueger J, Lefohn AE, et al., *A Survey of General-Purpose Computation on Graphics Hardware,* Computer Graphics Forum. 2007;26(1):80–113
[2] Langs A, Biedermann M., *Filtering Video Volumes Using the Graphics Hardware*, Ersbøll BK, Pedersen KS, editors. SCIA. vol. 4522 of Lecture Notes in Computer Science. Springer; 2007. 878–887
[3] Köhn A, Drexl J, Ritter F, König M, Peitgen HO, *GPU Accelerated Image Registration in Two and Three Dimensions*. Bildverarbeitung für die Medizin 2006. Springer; 2006. 261–265
[4] MeVis Research GmbH, *MeVisLab: A Development Environment for Medical Image Processing and Visualization*; 2007. , `http://www.mevislab.de`

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