Evaluation and Exploration of Next Generation Systems for Applicability and Performance

Volodymyr Kindratenko
Guochun Shi

Plan of work for Q4

- Develop a stand-alone C test-bed of the image extraction component of doc2learn
  - integrate the developed image probability density function computation algorithm (both the CPU and GPU implementations)
  - investigate how to extend the CPU implementation of the histogram computation to the multi-core architecture of modern CPUs
  - conduct a study how the stand-alone implementation compares to the original doc2learn Java-based implementation
  - use the stand-alone framework to analyze power consumption of the CPU and GPU implementations
    - Integrate new power monitoring hardware
- Investigate other image comparison algorithms and their suitability for GPU acceleration
- Investigate pros and cons of extending Versus framework to use GPU-based image processing algorithms

Stand-alone C test-bed of the image extraction component of doc2learn

- *Integrate the developed image probability density function computation algorithm (both the CPU and GPU implementations)*

- Based on xpdf-3.02, with the following modifications
  - Replaced method ImageOutputDev::drawImage with the code for computing image histogram
    - Computes histogram of an image and stores it in a file
  - Added new method ImageStream::getLine to extract one image row directly into user-supplied buffer
    - Eliminates a memcopy
- No GPU code has been integrated yet

Stand-alone C test-bed of the image extraction component of doc2learn

- *Investigate how to extend the CPU implementation of the histogram computation to the multi-core architecture of modern CPUs*

- Not done yet

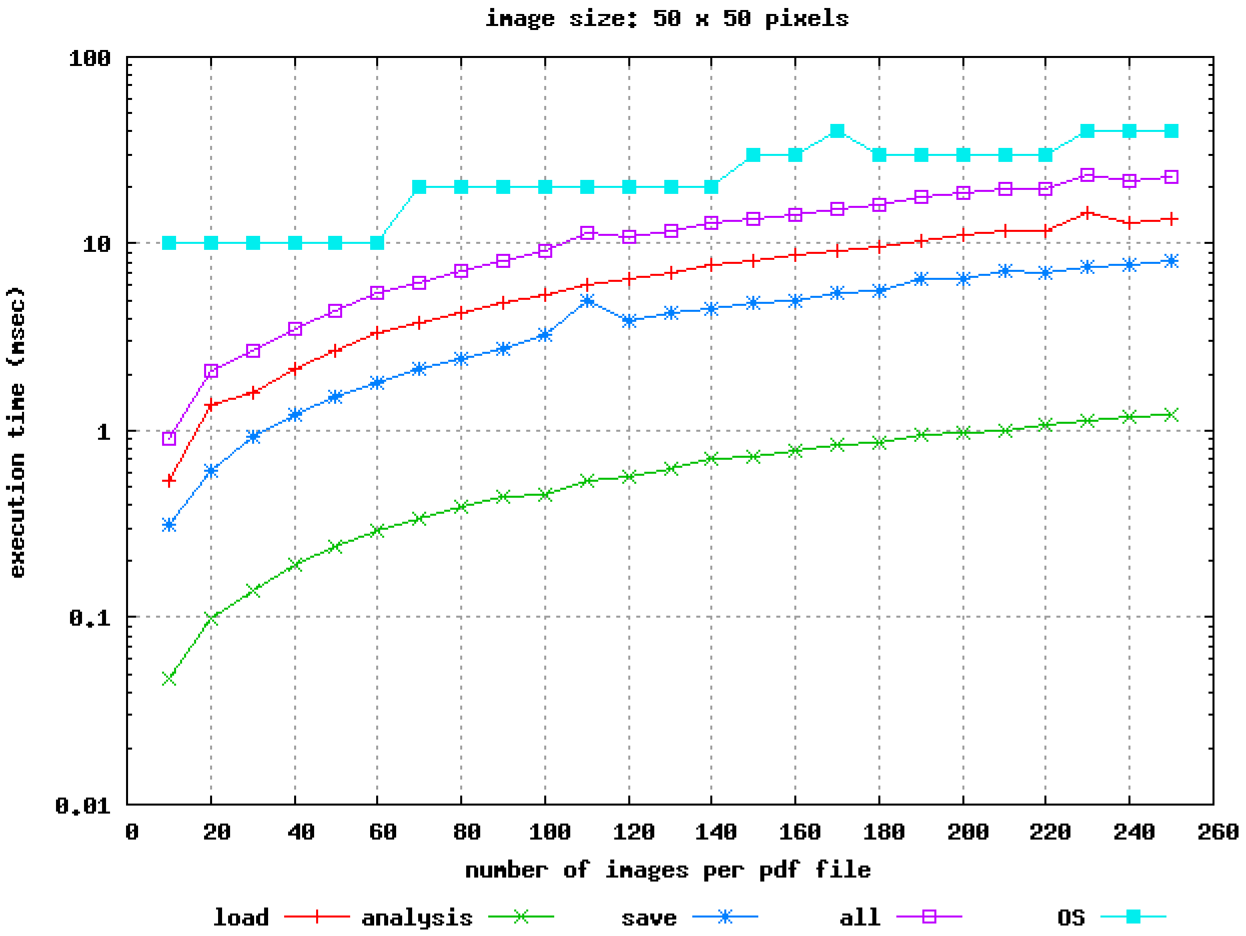
Stand-alone C test-bed of the image extraction component of doc2learn

- *Conduct a study how the stand-alone implementation compares to the original doc2learn Java-based implementation*

- Work in progress

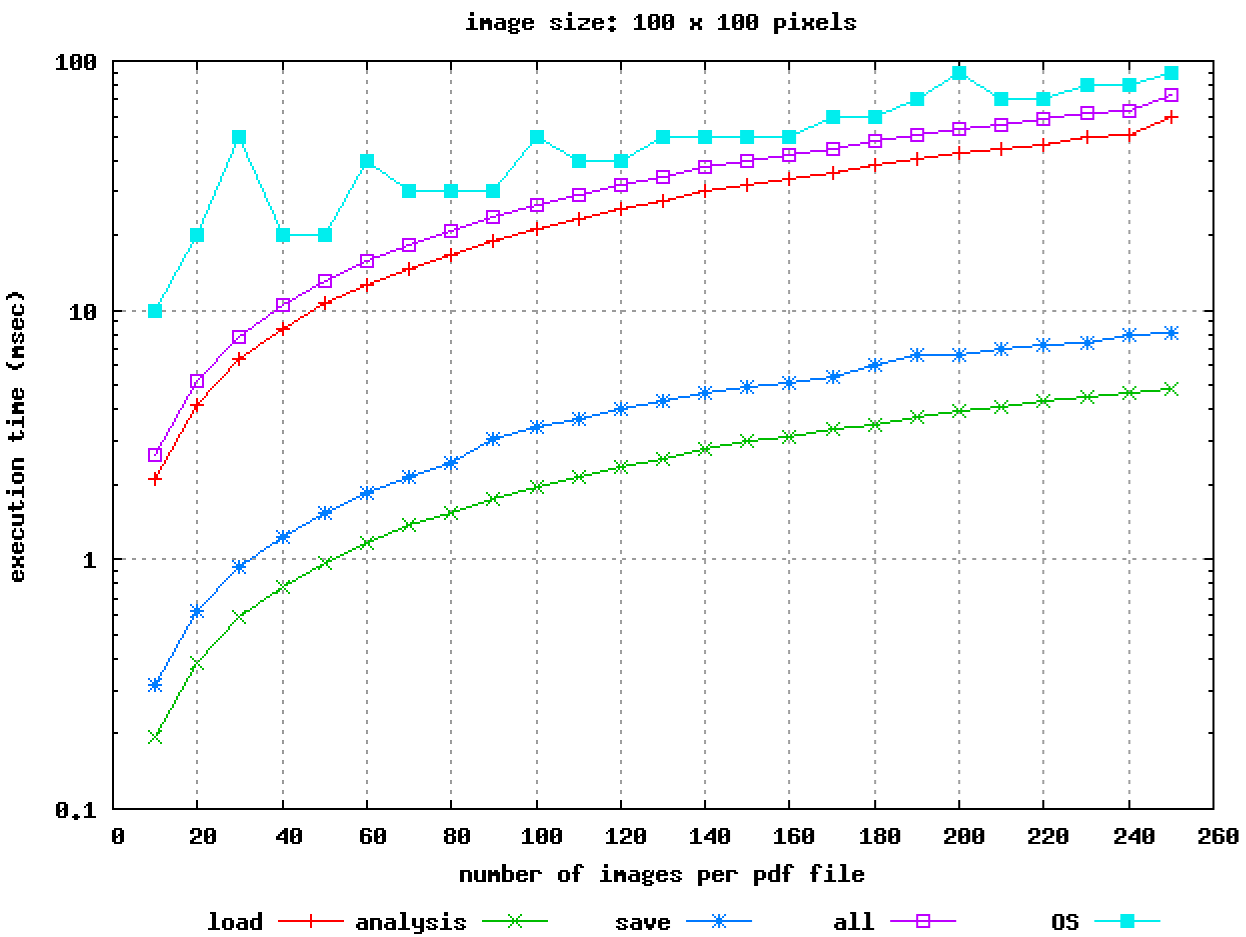
Effects of image size

- 50x50
- /tmp



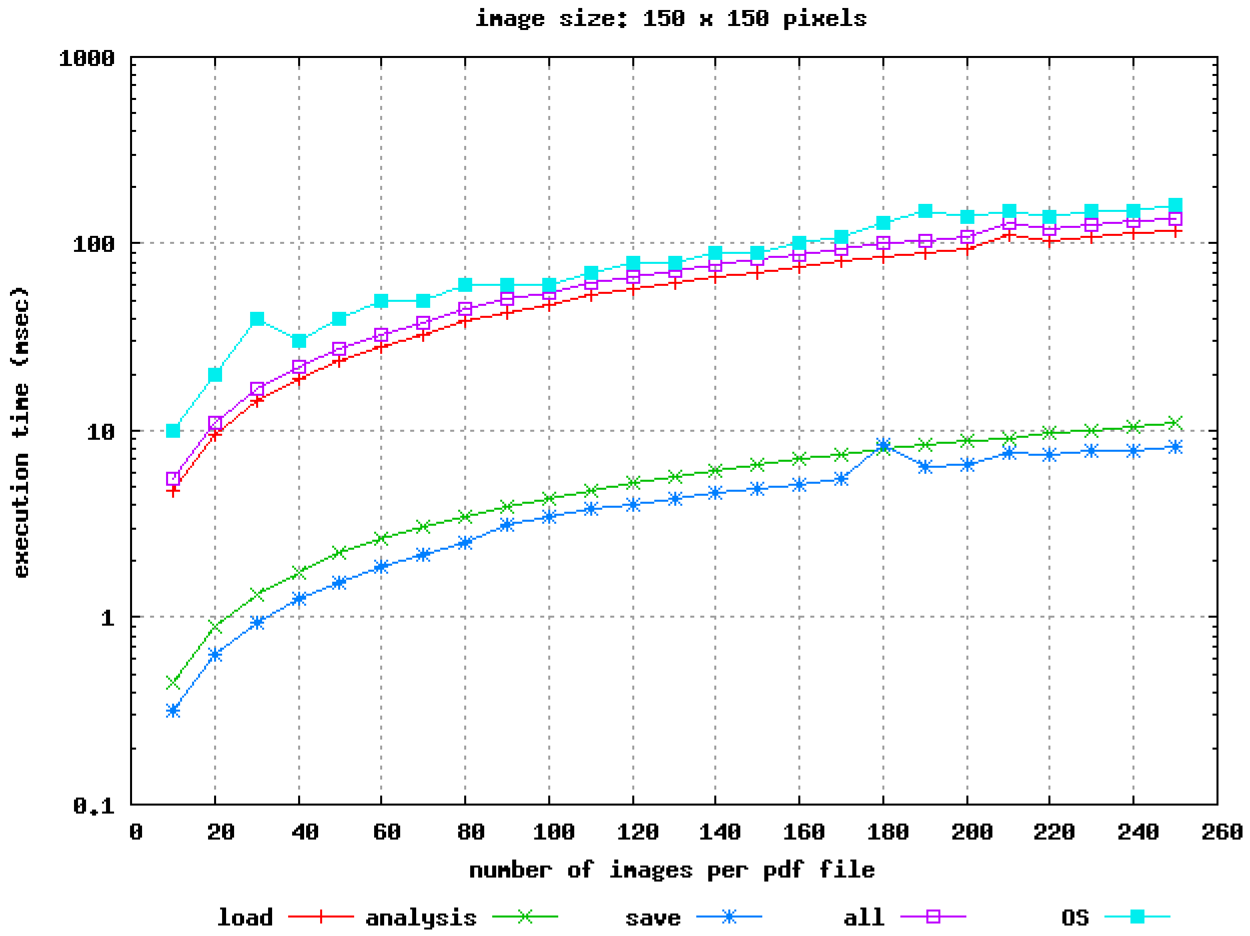
Effects of image size

- 100x100
- /tmp



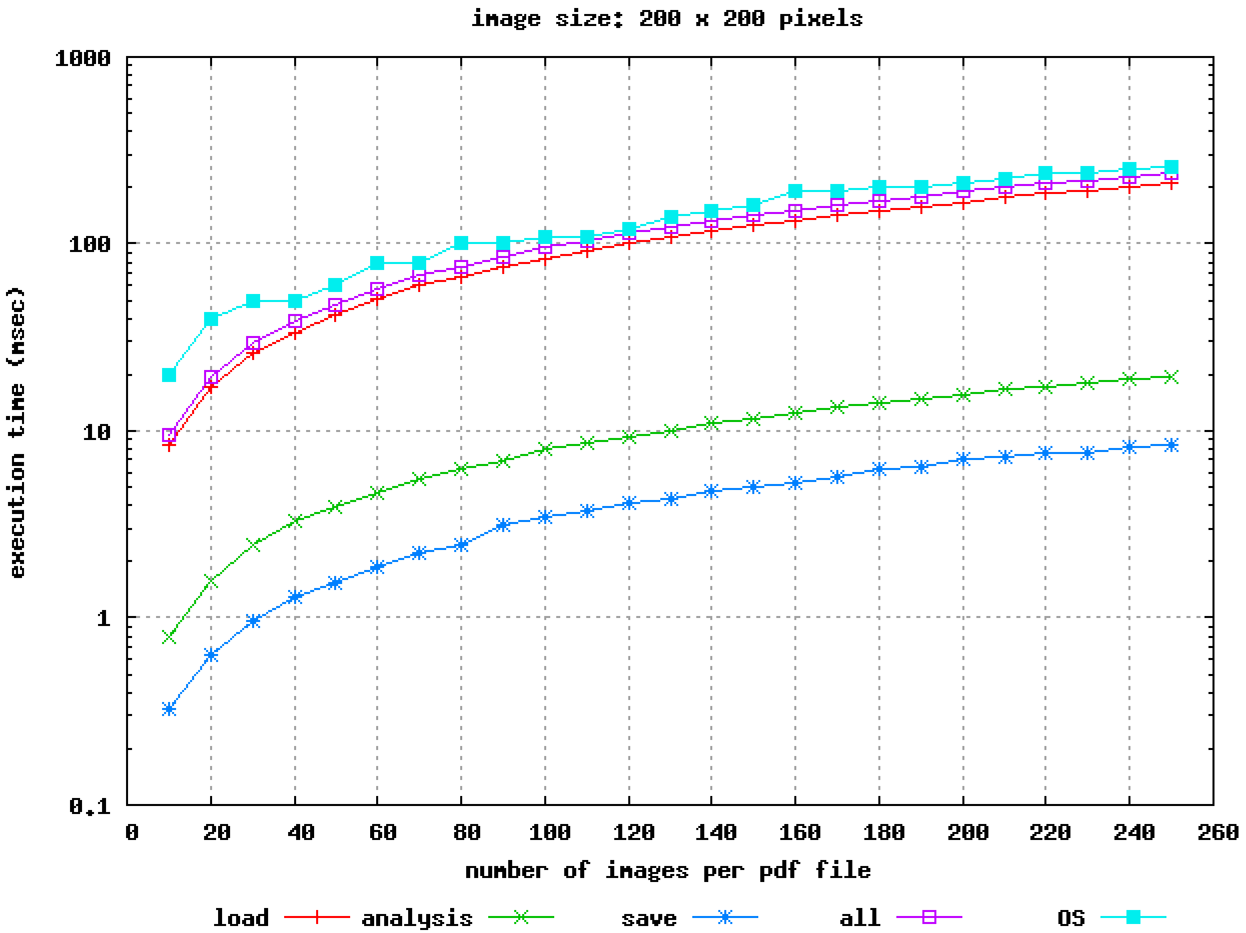
Effects of image size

- 150x150
- /tmp



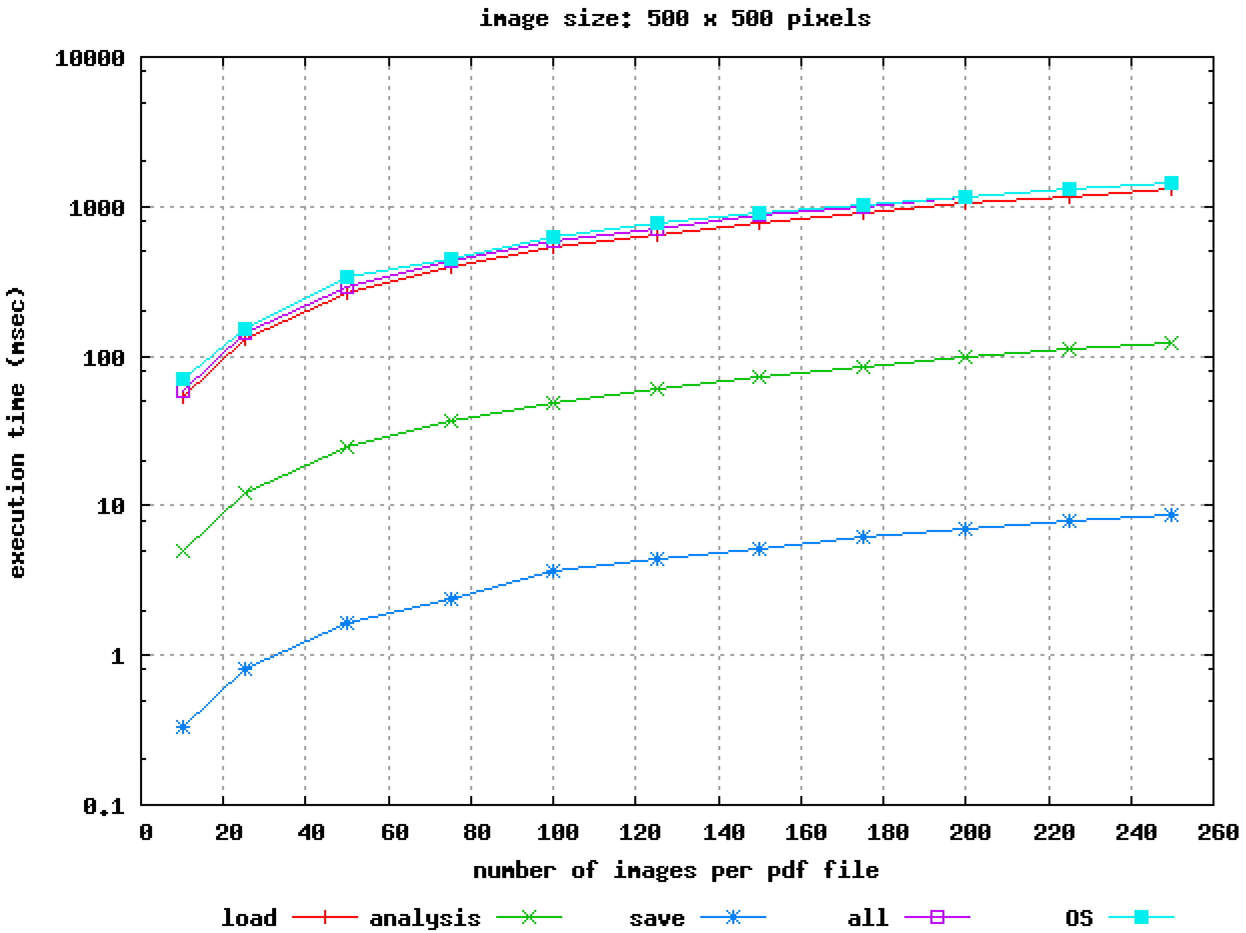
Effects of image size

- 200x200
- /tmp



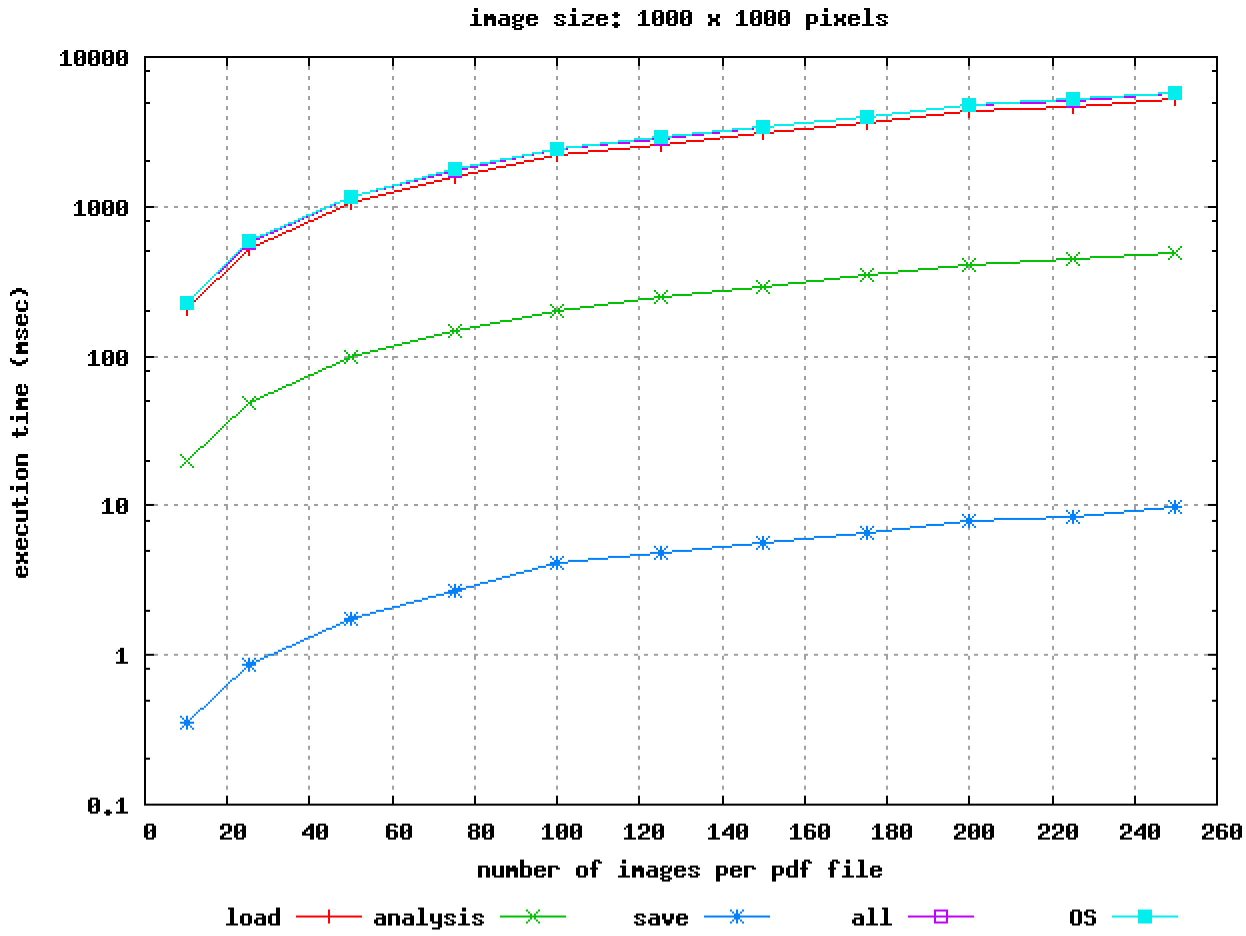
Effects of image size

- 500x500
- /tmp



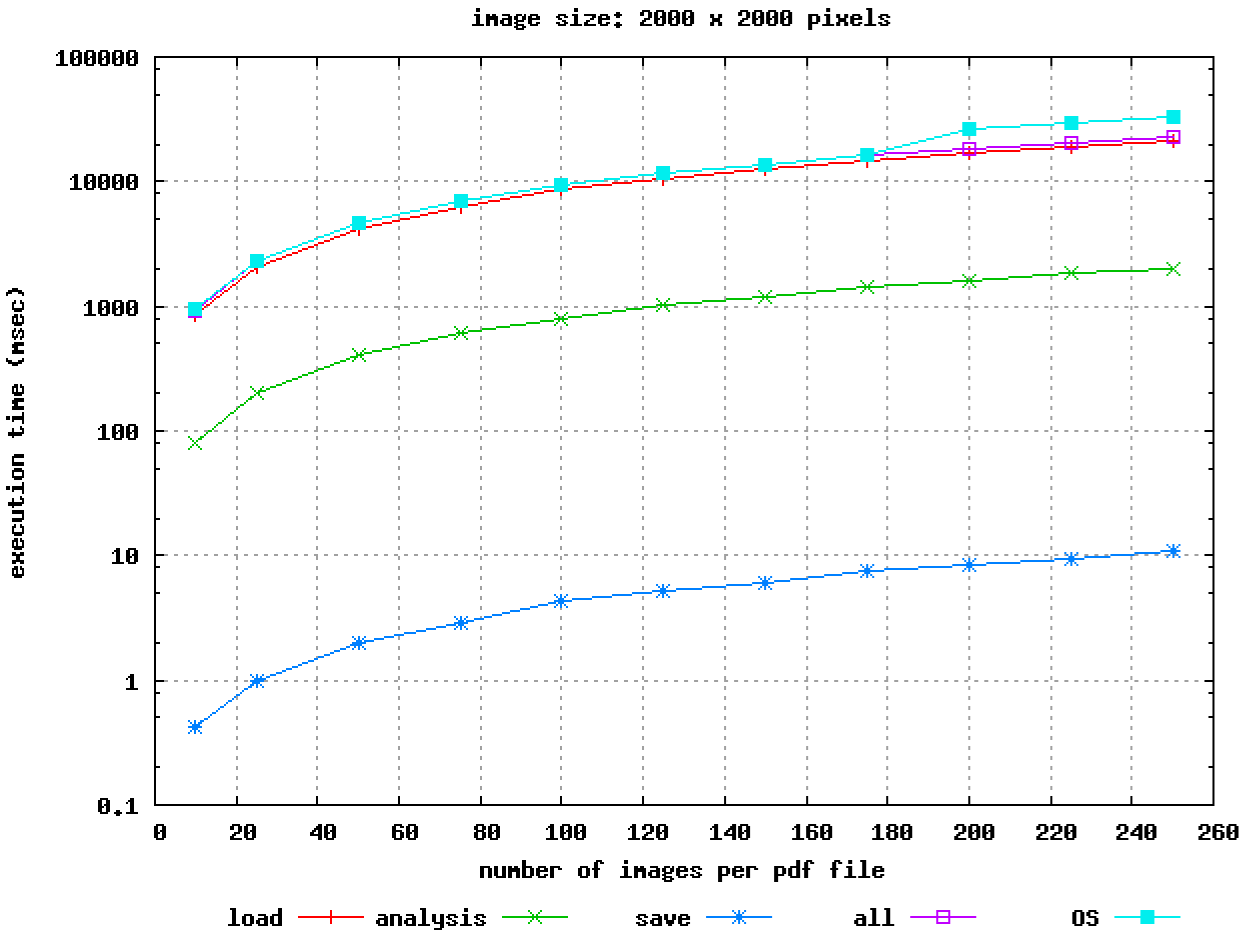
Effects of image size

- 1Kx1K
- /tmp



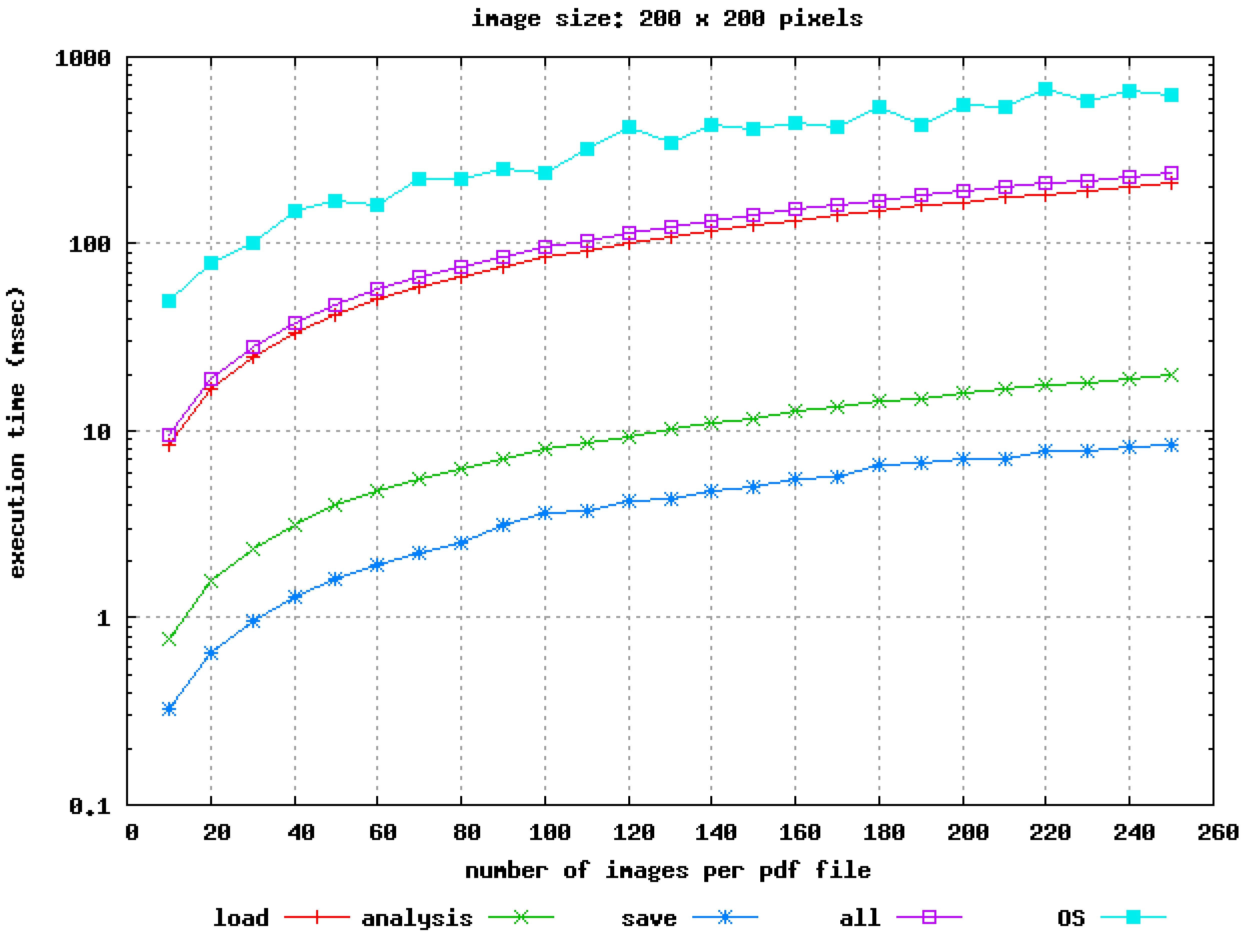
Effects of image size

- 2Kx2K
- /tmp



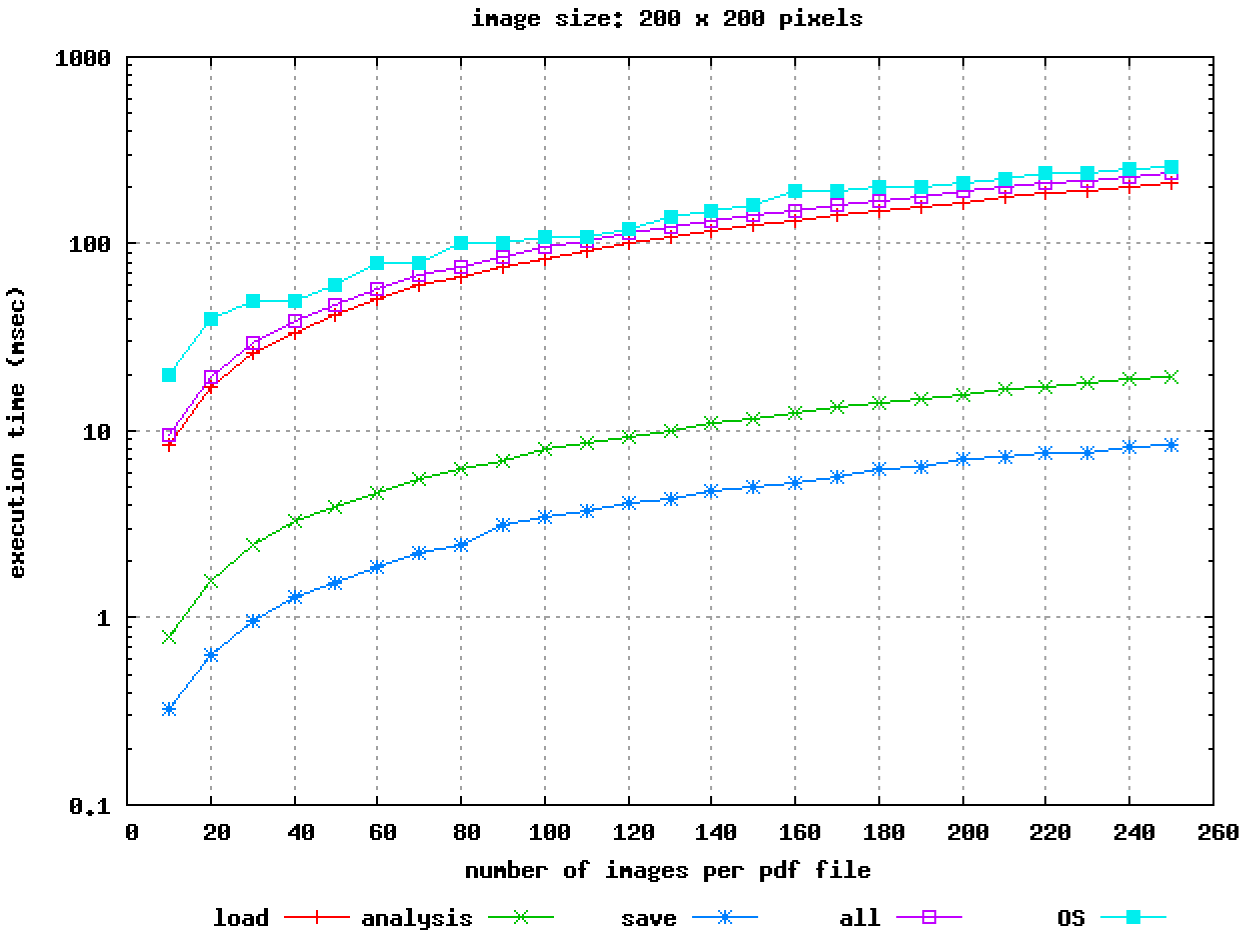
Effects of file system type

- nfs
- 200x200



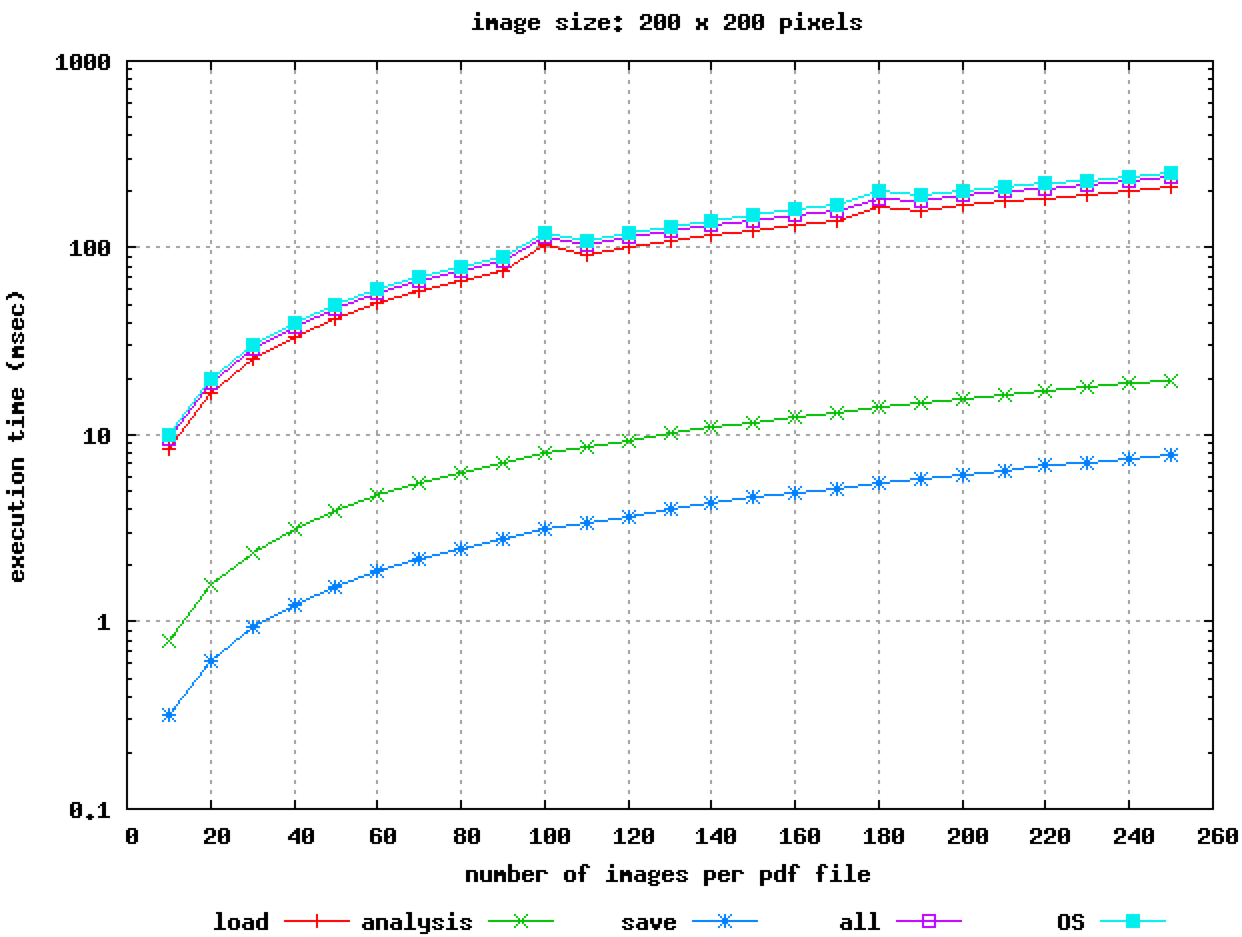
Effects of file system type

- /tmp
- 200x200

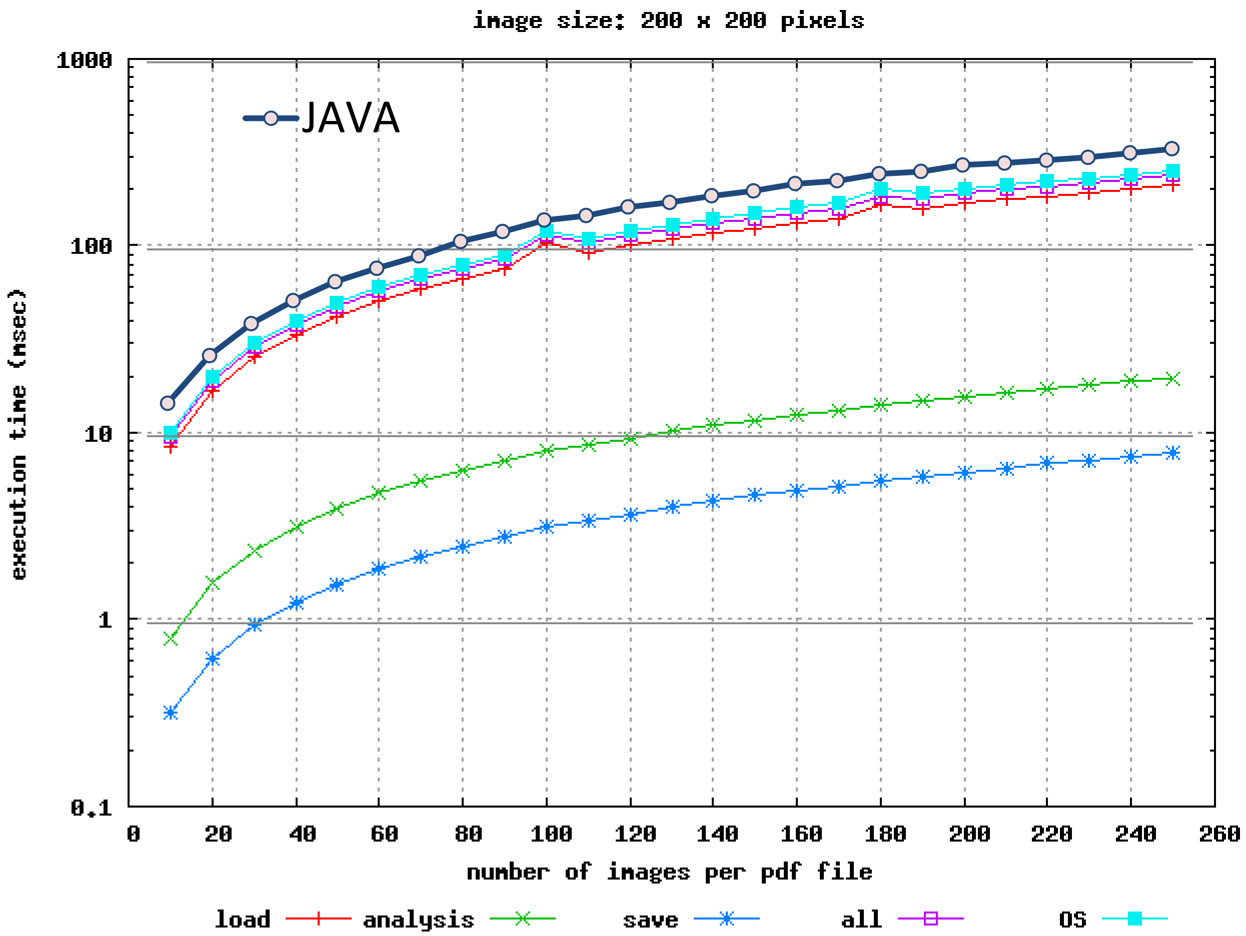


Effects of file system type

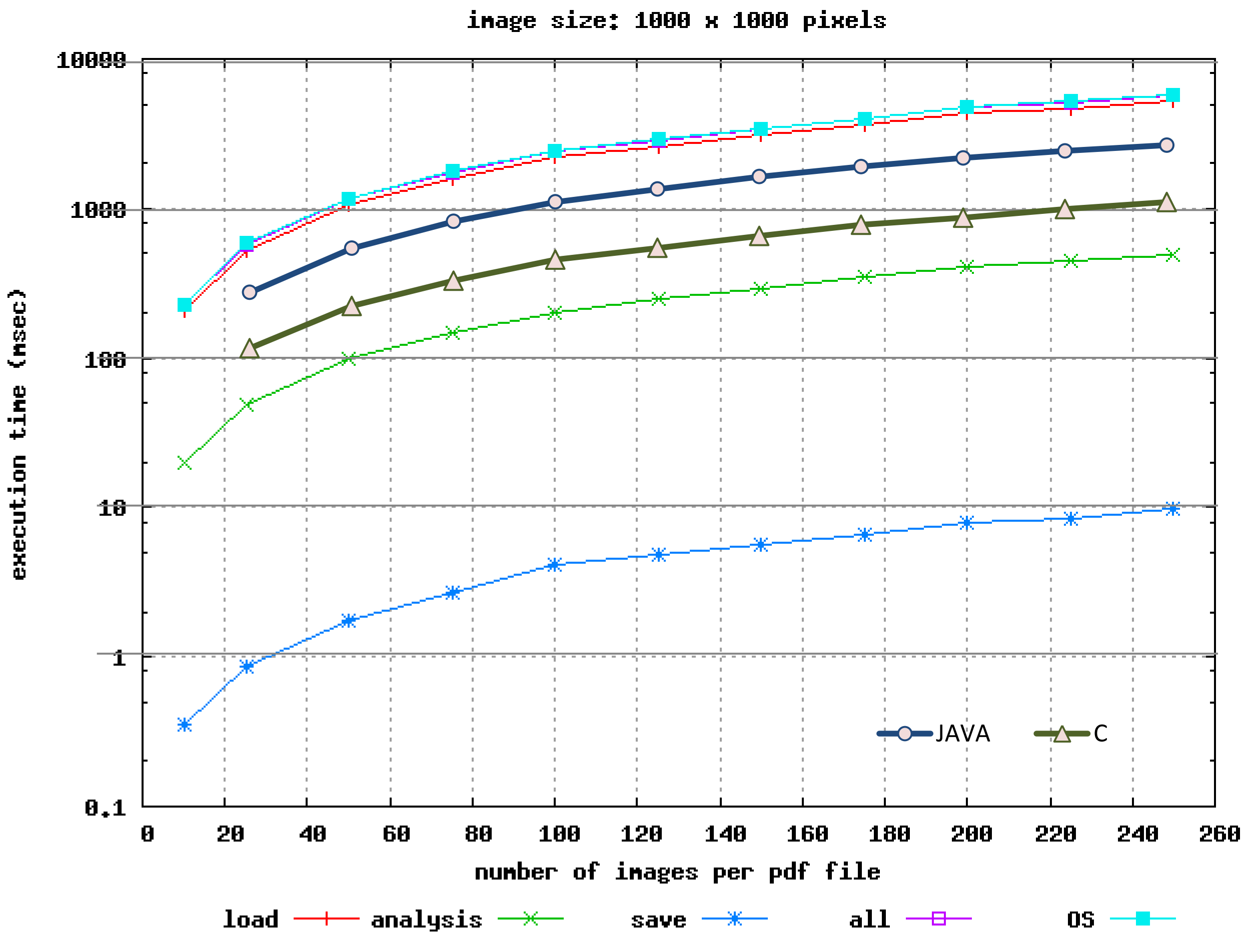
- ramdisk
- 200x200



Comparison with doc2learn



Comparison with doc2learn



Observations/Conclusions

- Stand-alone C-based implementation is substantially faster than the Java-based framework
  - For small images, the entire application runs faster than Java-based image analysis part of doc2learn (not even including file I/O)
  - For larger images, Java-based image analysis code is still substantially slower
- Reading images from disk takes an order of magnitude more time than to compute histograms
  - Overall application speedup of no more than 10% can be achieved by speeding up the image processing time
  - Does a 10% speedup really matter?

- Suggestions for improving doc2learn performance without GPUs:
  - Save all histograms for a given PDF file into just **one** output file
    - Otherwise saving computed histograms to disk takes more time than to compute them
    - fopen/fclose are very expensive
  - Use ramdisk to temporary store PDF files while processing them
    - Eliminates OS jitter due to disk access

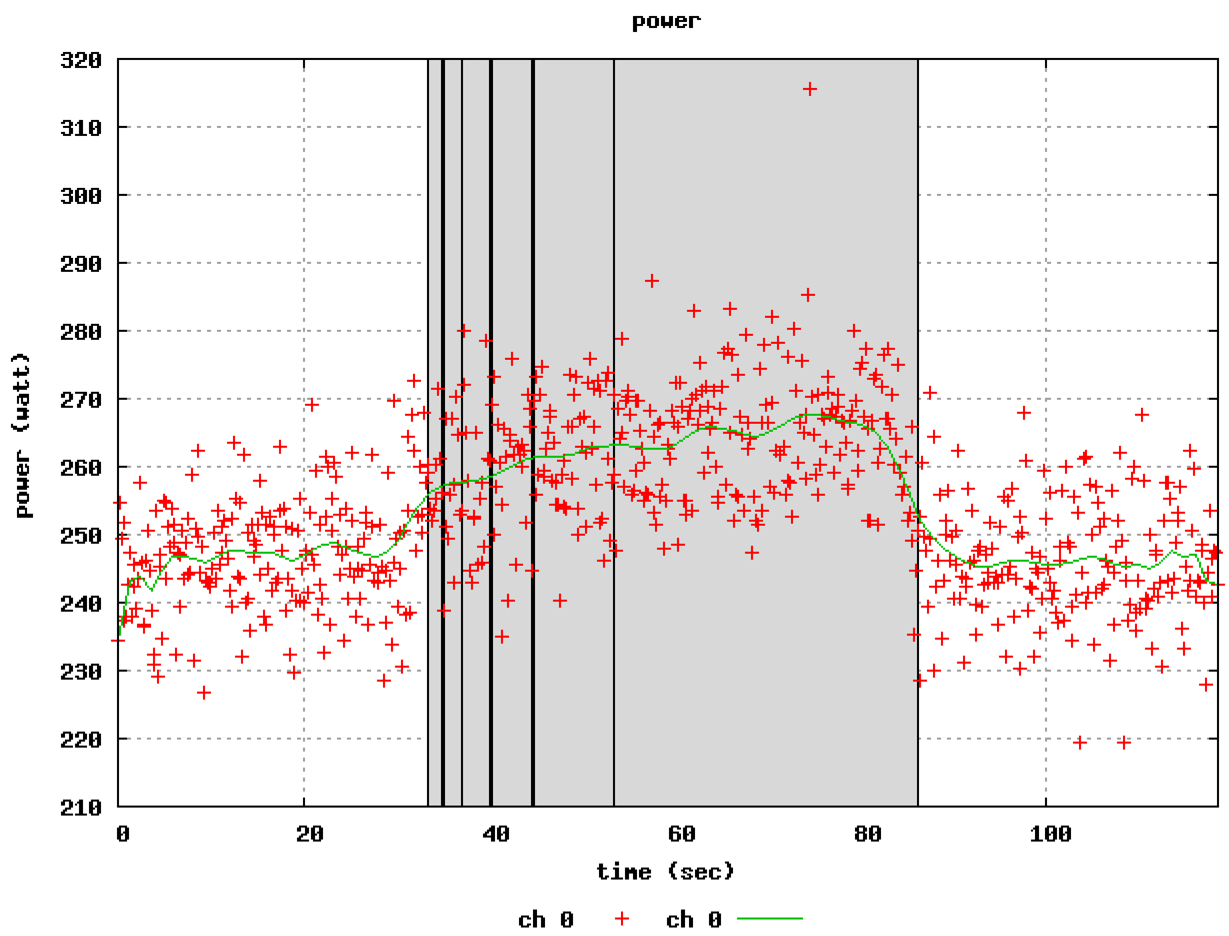
Stand-alone C test-bed of the image extraction component of doc2learn

- *Use the stand-alone framework to analyze power consumption of the CPU and GPU implementations*
  - *Integrate new power monitoring hardware*

- Based on the new power monitoring hardware developed at ISL by Craig Steffen
  - We wrote data acquisition and analysis scripts necessary to collect and visualize power levels

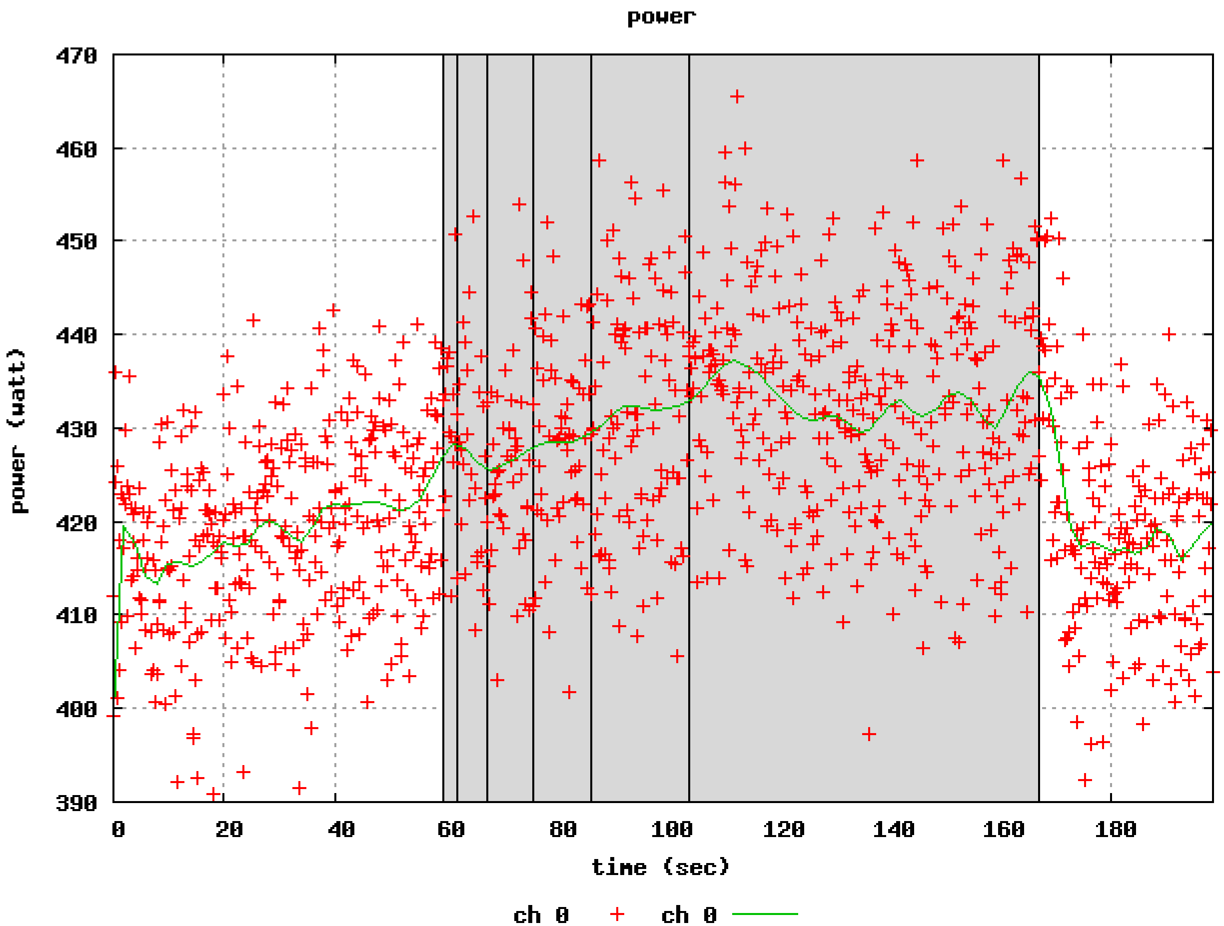
Power consumption measurements

- /tmp
- 50-1K
- idle
  - ~247 watt
- computing
  - ~265 watt
- Δ ~18 watt



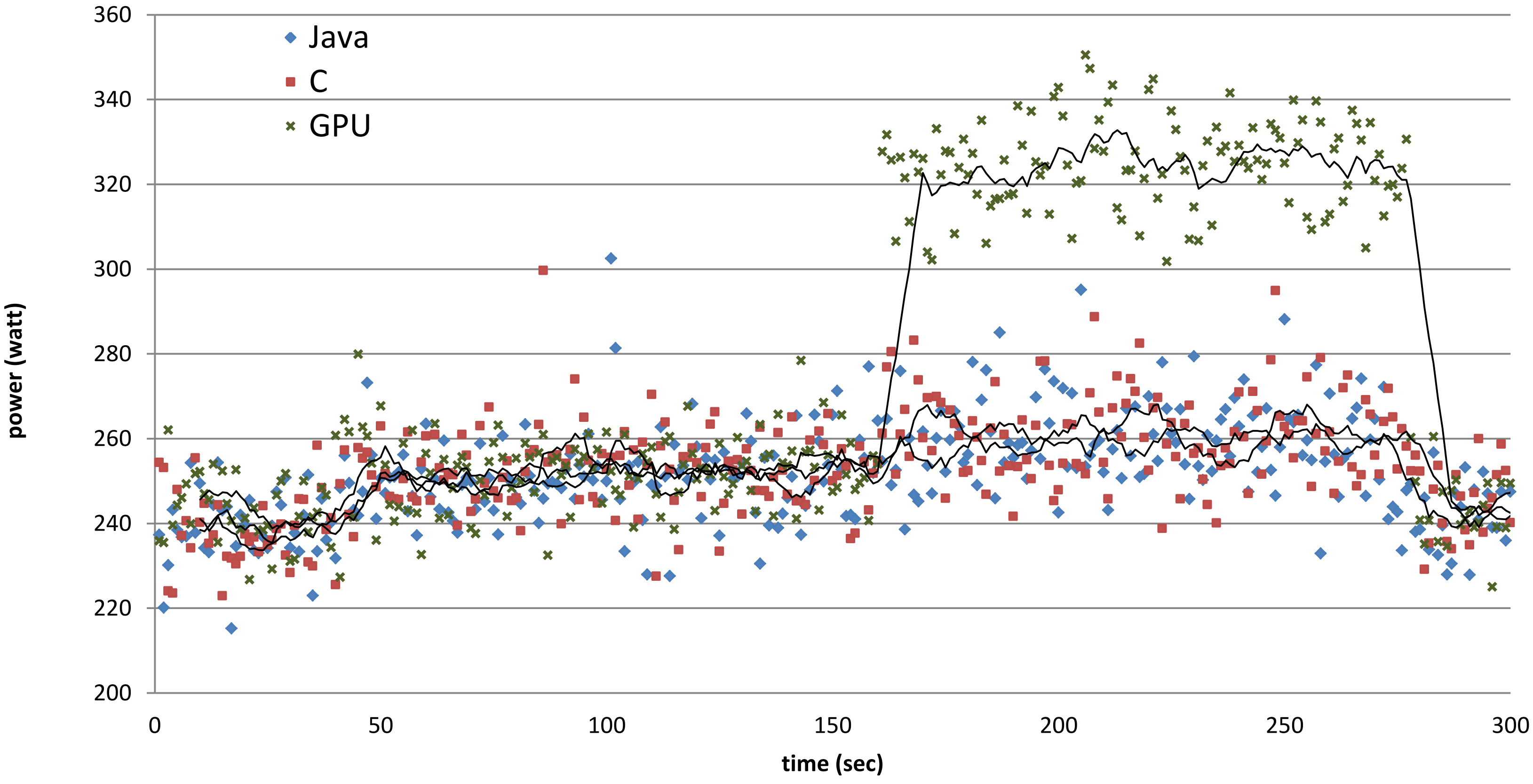
Power consumption measurements

- /tmp
- 50-2K
- “idle”
  - ~418 watt
- computing
  - ~432 watt
- Δ ~14 watt



Doc2learn power efficiency analysis

- 2Kx2K images, 250 image count



Doc2learn power efficiency analysis

Image size/ count	Image analysis only		Image extraction and analysis	
	1000x1000/250	2000x2000/250	1000x1000/250	2000x2000/250
t (sec)	2.749	10.322	25.684	107.999
t_c (sec)	1.131	4.575	24.438	102.682
t_g (sec)	0.950	3.763	24.327	98.474
p (watt)	260	260	260	260
p_c (watt)	260	260	260	260
p_g (watt)	325	325	325	325
$s_c=t_c/t$	2.43	2.26	1.05	1.05
$s_g=t_g/t$	2.89	2.74	1.06	1.10
$e_c=p/p_c*s_c$	2.43	2.26	1.05	1.05
$e_g=p/p_g*s_g$	2.31	2.19	0.84	0.88

If we **do not** take into account image extraction time (which is huge compared to the image processing time), GPU-based implementation is more power-efficient.

If we **do** take into account the image extraction time, GPU-based implementation becomes power-inefficient!

Other topics

- Investigate other image comparison algorithms and their suitability for GPU acceleration
  - Work in progress

- Investigate pros and cons of extending Versus framework to use GPU-based image processing algorithms
  - Work in progress

Future work

- Finish image analysis work
  - Perform final set of measurements
  - Write report
- New directions (after phone calls with Mark Conrad and Richard Lopez)
  - Data compression on GPUs
  - Computing file checksums on GPUs
  - Investigating applicability of database appliances for iRODS
    - XtremeData's dbX Data Warehousing Appliance