JPEG 2000 Image Codecs Comparison

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Tested codecs:

- JASPER 1.701.0
- ACDSee 7.0
- Leadtools JPEG 2000 Photoshop plug-in 1.0
- Morgan JPEG 2000 toolbox 1.2 rev 0.0
- Lurawave 2.1.10.04
- Kdu_compress 4.5.2
- JPEG 2000 Compressor (Anything 3D) 1.00.000
- Elecard Wavelet 3.0 Beta
- Photoshop CS2 'native' plug-in 1.6

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Overview

Codecs

Codec	Manufacturer	Version
JPEG (not JPEG 2000)	Adobe Systems Inc.	7.0
JASPER	Michael Adams	1.701.0
ACDSee	ACD Systems	7.0
Leadtools JPEG 2000 Photoshop plugin	Leadtools Technologies	1.0
Morgan JPEG 2000 toolbox	Morgan Multimedia	1.2 rev 0.0
Lurawave	LuraTech	2.1.10.04
Kdu_compress	Kakadu Software	4.5.2
JPEG 2000 Compressor (Anything 3D)	Anything 3D Corp	1.00.000
Elecard Wavelet	Elecard Inc.	3.0 Beta
Photoshop CS2 'native' plugin	Adobe Systems Inc.	1.6

Codecs' settings

Codec	Parameter	Values
Jpeg (not JPEG 2000 standard)	quality	0, 1, 2, 3, 6, 9
JASPER	rate	0.01, 0.024, 0.04, 0.06, 0.09, 0.107
ACDSee	compression ratio	100, 43, 25, 17, 12, 9
Leadtools JPEG 2000 Photoshop plugin	compress. ratio	100, 43, 25, 17, 12, 9
Morgan JPEG 2000 toolbox	quality	3, 7, 12, 18, 26, 31
Lurawave	quality	10, 30, 50, 70, 90, 100
Kdu_compress	bps	0.24, 0.56, 0.96, 1.44, 2.16, 2.56
JPEG 2000 Compressor (Anything 3D)	quality	5, 10, 20, 30, 40, 53
Elecard Wavelet	compress factor	1, 2, 4, 6, 9, 12
Photoshop CS2 'native' plugin	file size (kb)	7, 18, 31, 47, 68, 82

Other codecs' settings were left with their default values. You can see them on screenshots of codecs' interfaces.

Images used for test

Image	Uncompressed file size	Resolution
Barbara	786486 bytes	512x512
Lenna	786486 bytes	512x512
Lighthouse	786486 bytes	512x512
House	786486 bytes	512x512

Goals and rules of testing

JPEG 2000 codecs testing goal

JPEG 2000 is a new image compression format. It was developed to replace JPEG and has a number of advantages: higher compression rates are available, improved lossless mode, progressive visualization, scaling, error correction, etc. Images in this format are not yet popular, but it has all chances to become a substitute for JPEG. **The main goal of this testing was the comparison of compression quality of JPEG 2000 codecs: is there any significant difference between implementation of this standard?** Only compression quality was compared. Codecs have been tested on standard test images, all codecs settings were set to defaults except for compressed image quality.

Rules of the testing

- PSNR was calculated using MSU Video Quality Measurement Tool. www.compression.ru/video/quality_measure/video_measurement_tool_en.html
- Compressed image quality was chosen to get approximately same size of output file for all codecs.
- All codecs' parameters (except for picture quality) were set to defaults (default settings are settings specified in codec after its installation).
- For Photoshop CS2 parameter "save meta data" was switched off.

Images used in the testing

Barbara

Barbara.bmp (50% size)

Name	Barbara
Resolution	512x512
Features	Black and white image. Main feature – stripes on table-cloth, on scarf and on pants where moire and other artifacts often appear.

Lenna

Lenna.bmp (50% size)

Name	Lenna
Resolution	512x512
Features	Classical test image. Smooth color changes, borders.

Lighthouse

Lighthouse.bmp (50% size)

Name	Lighthouse
Resolution	512x512
Features	Main features are sky, white fence, hand-rail on top of the lighthouse. By amount of their details it is possible to evaluate compression quality.

House

House.bmp (50% size)

Name	House
Resolution	512x512
Features	Lots of high-frequency regions that are badly affected by compression (grass, leaves). Bright borders on the roof.

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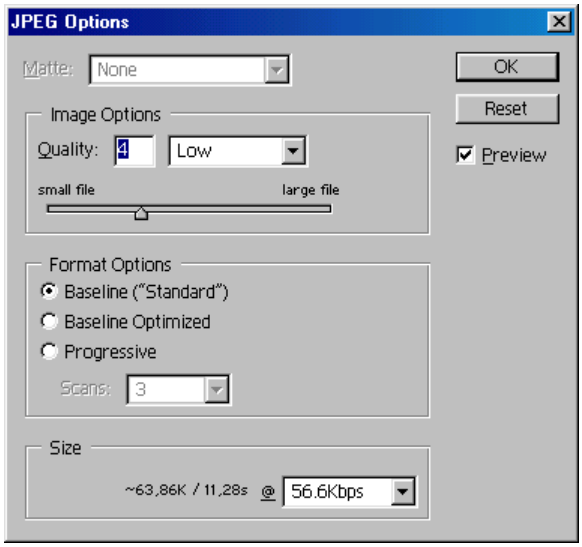
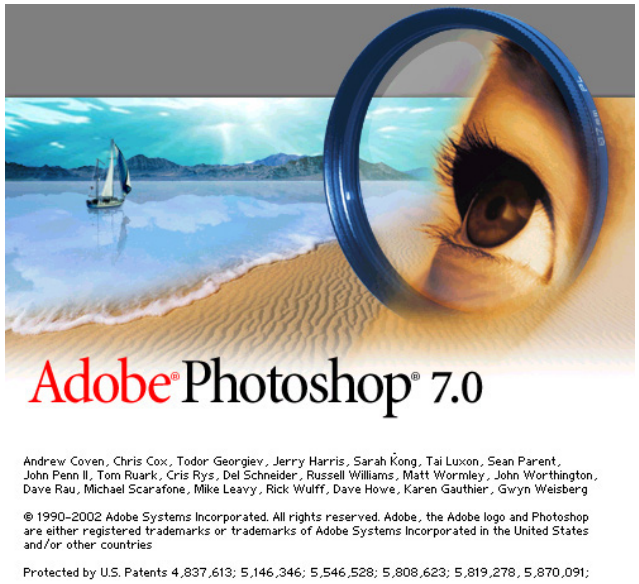
Codecs used in the testing

JPEG from Adobe Photoshop version 7.0

This codec was used to compare possibilities of JPEG and JPEG2000. This is the single JPEG codec tested; it is included in Adobe Photoshop 7.0. 'Quality' parameter was varied.





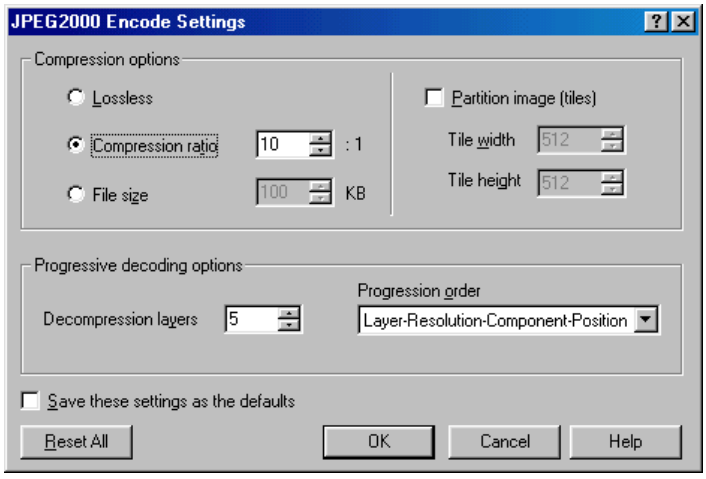
JASPER 1.701.0

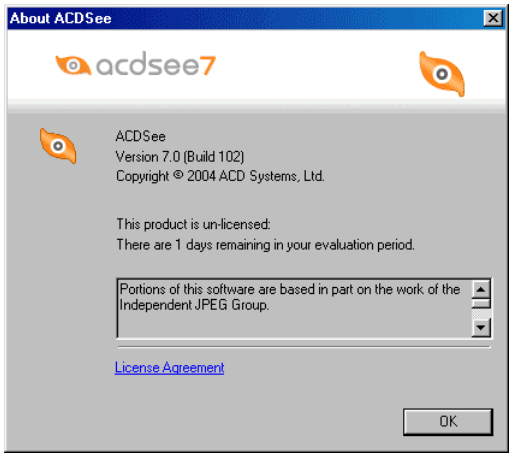
Command line codec. This codec is included in JPEG 2000 standard as reference implementation. 'Rate' parameter was varied. Following line was used for testing:

```
jasper.exe --input in.bmp --output out.jp2 -O rate=0.09
```

ACDSee 7.0

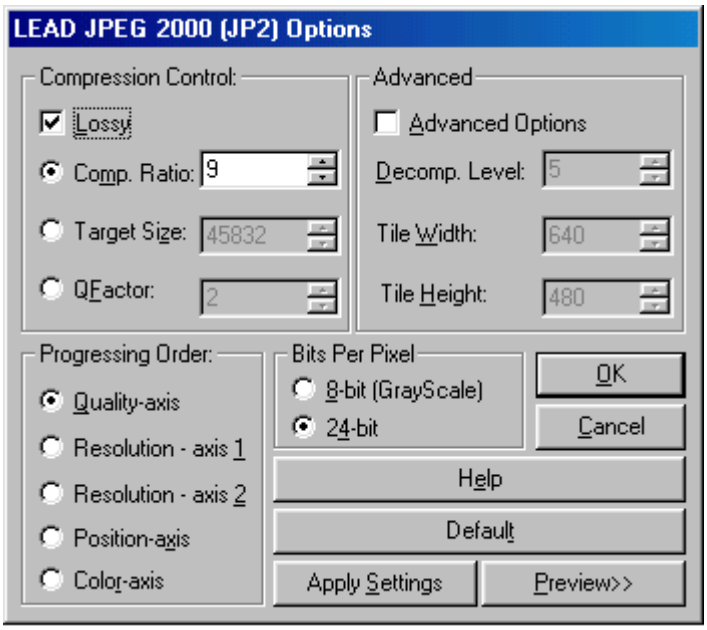
'Compression ratio' parameter was varied.





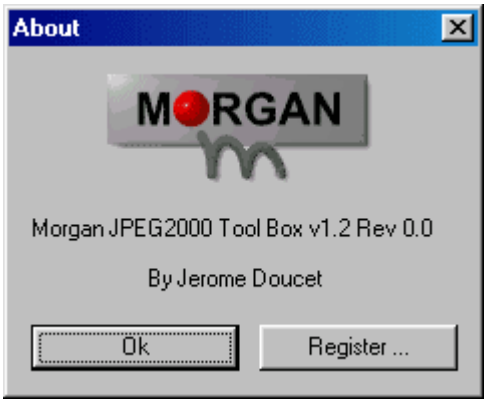
Leadtools JPEG 2000 Photoshop plugin 1.0

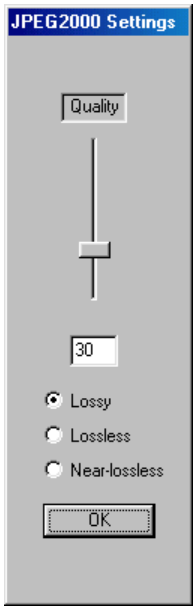
'Comp. Ratio' parameter was varied.



Morgan JPEG 2000 toolbox 1.2 rev. 0.0

'Quality' parameter was varied. Codec was inconvenient for testing: different 'Quality' values sometimes give same compressed file size.





Lurawave 2.1.10.04

Command line codec. 'Qual' parameter was varied. Following line was used for testing:

```
jp2.exe c -i source.bmp -o output.jp2 -Qual 60
```

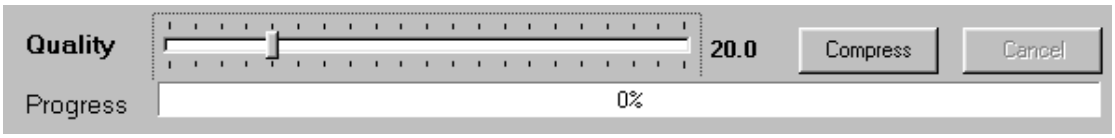
Kdu_compress 4.5.2

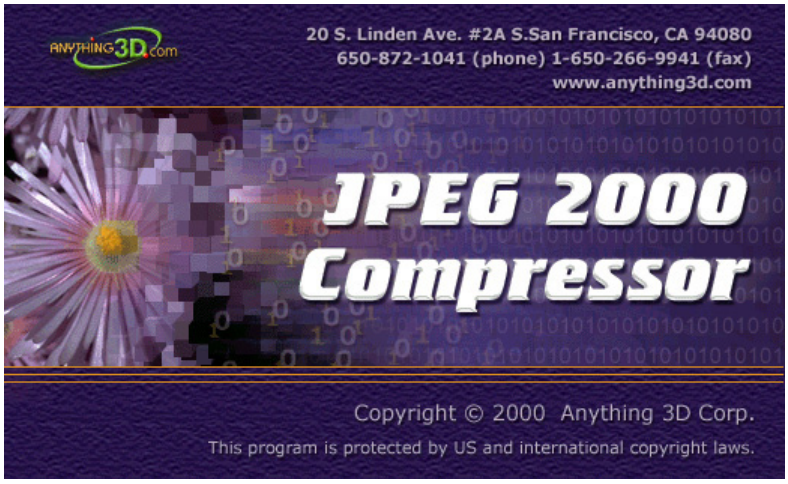
Command line codec. 'Rate' parameter was varied. Following line was used for testing:

```
kdu_compress.exe -i source.bmp -o target.jp2 -rate 0.09
```

JPEG 2000 Compressor (Anything 3D) 1.00.000

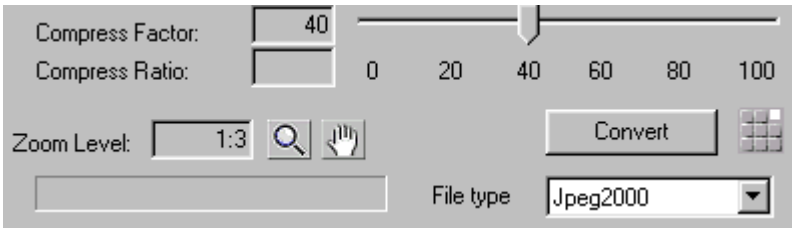
'Quality' parameter was varied.

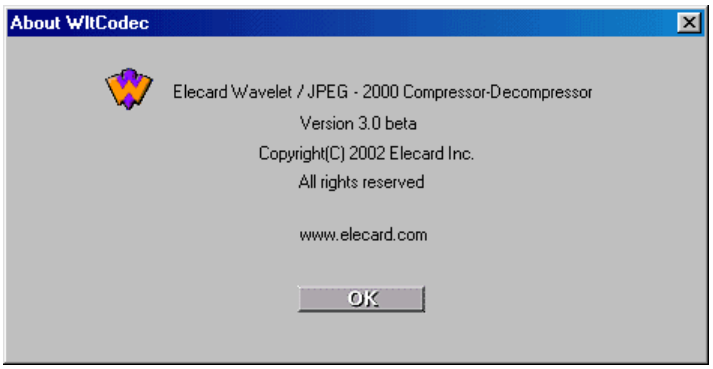




Elecard Wavelet 3.0 Beta

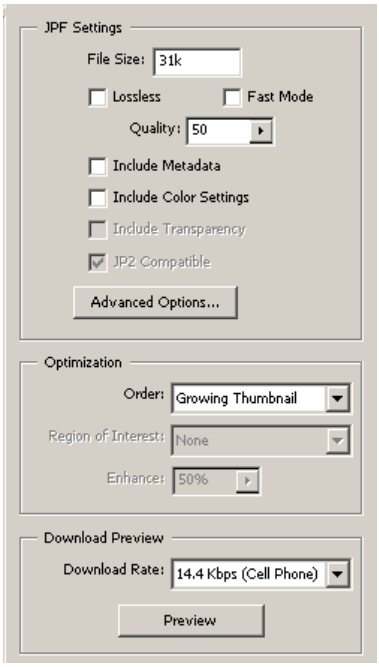
'Compress Factor' was varied.

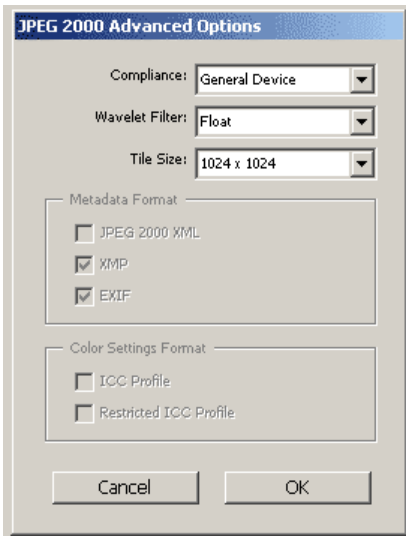


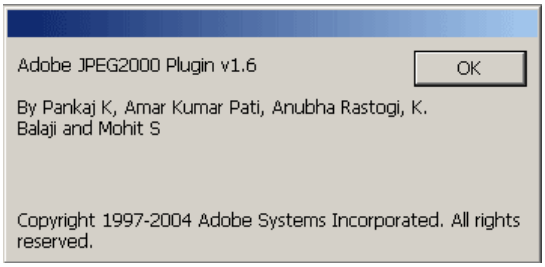


Photoshop CS2 'native' plugin, ver. 1.6

Codec from Adobe Photoshop CS2, version 9.0 was used for the testing. 'File Size' parameter was varied.







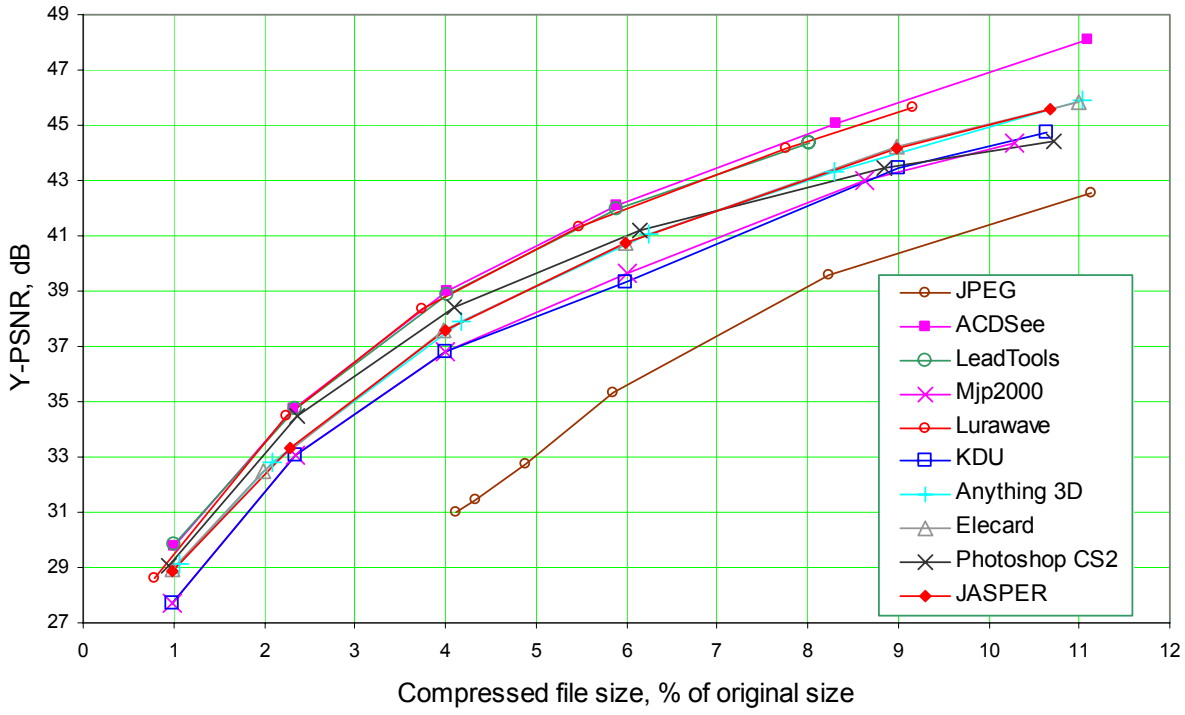
Y-PSNR/Compressed file size, Delta-Y-PSNR/Compressed file size diagrams

These diagrams clearly show the dependency of the compression quality from compression (size of compressed file divided by size of uncompressed file). PSNR metric is used for quality evaluation.

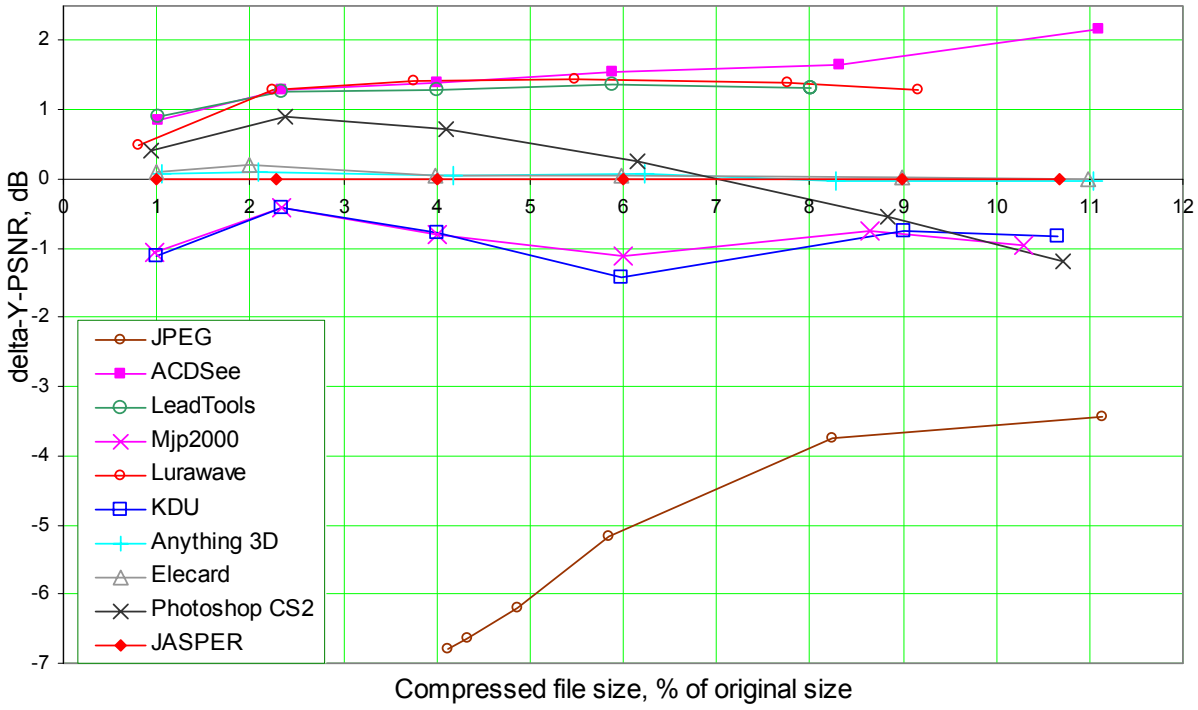
The higher level of PSNR measure (height of graphs) means better quality.

Delta Y-PSNR is the diagram of comparative PSNR value. **JASPER is included in JPEG 2000 standard as a reference implementation of the standard,** it corresponds to 0 on delta-PSNR graphs. PSNR values for JASPER are linearly interpolated to obtain values that correspond to any compressed file size for other codec.

Barbara image



Picture 1. Y-PSNR, Barbara

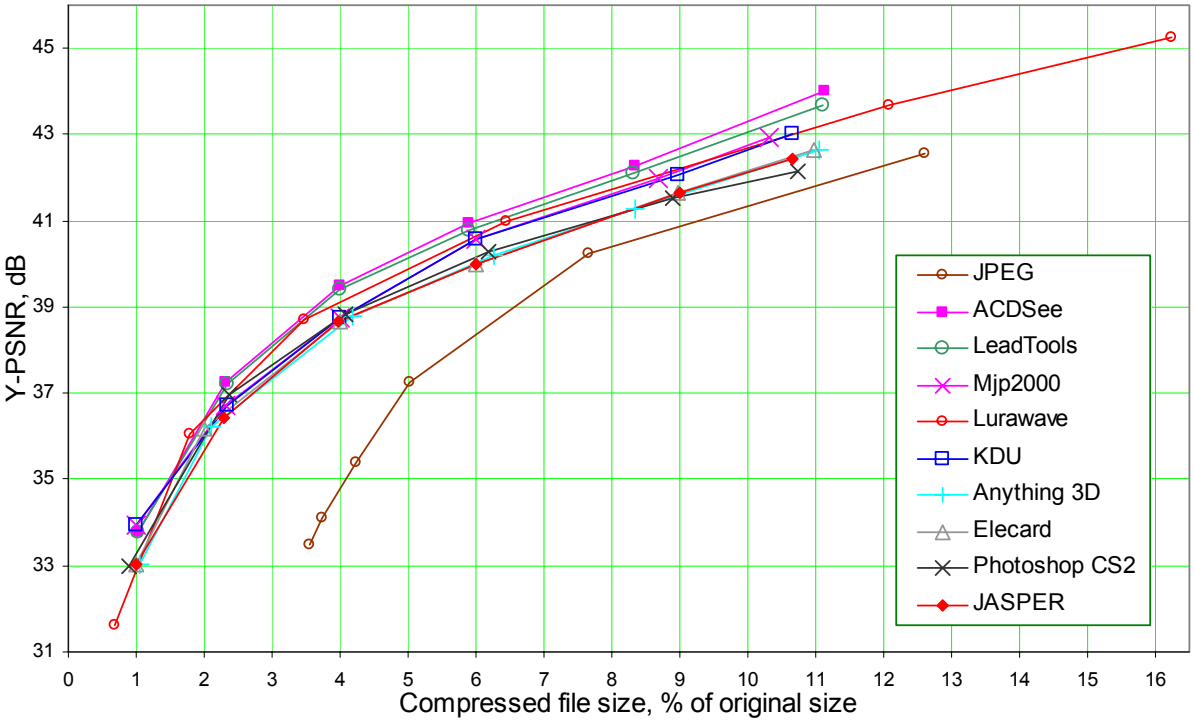


Picture 2. Delta-Y-PSNR, Barbara

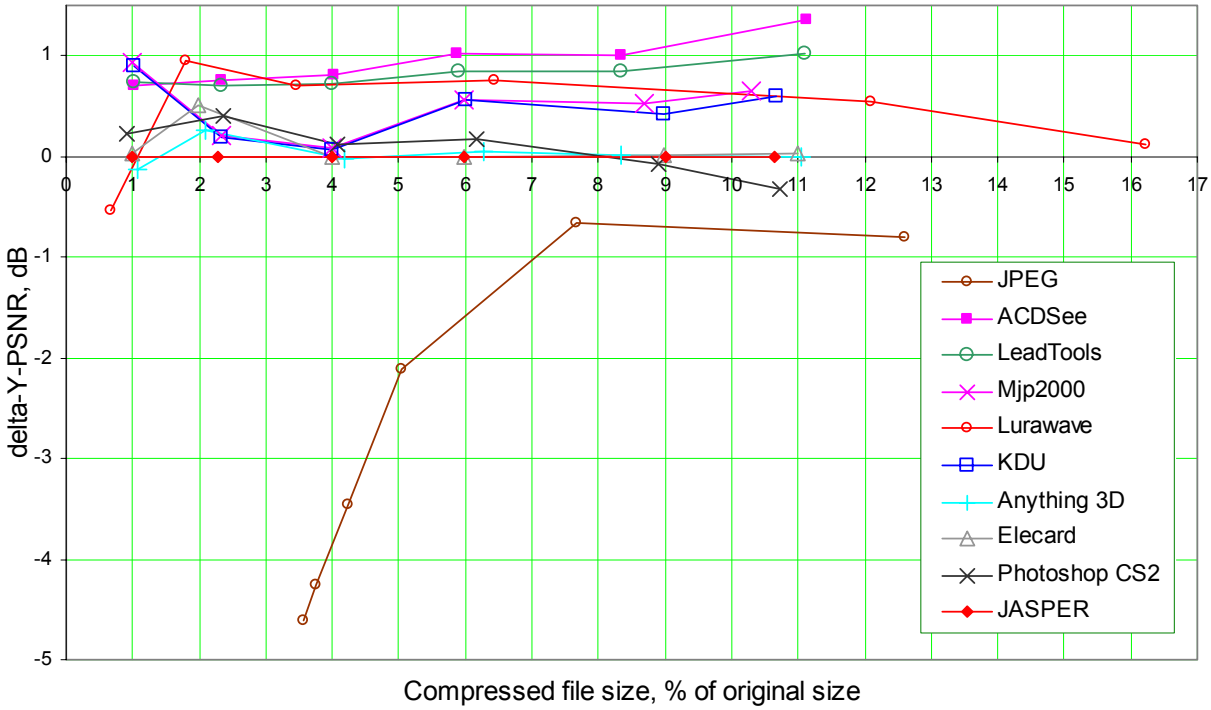
Conclusions:

- As it was expected, JPEG is far behind all JPEG 2000 codecs.
- ACDSee, LeadTools, Lurawave show best and similar performance.
- PSNR values for Morgan JPEG 2000 toolbox and KDU_compress are worse than values of reference codec.

Lenna image



Picture 3. Y-PSNR, Lenna

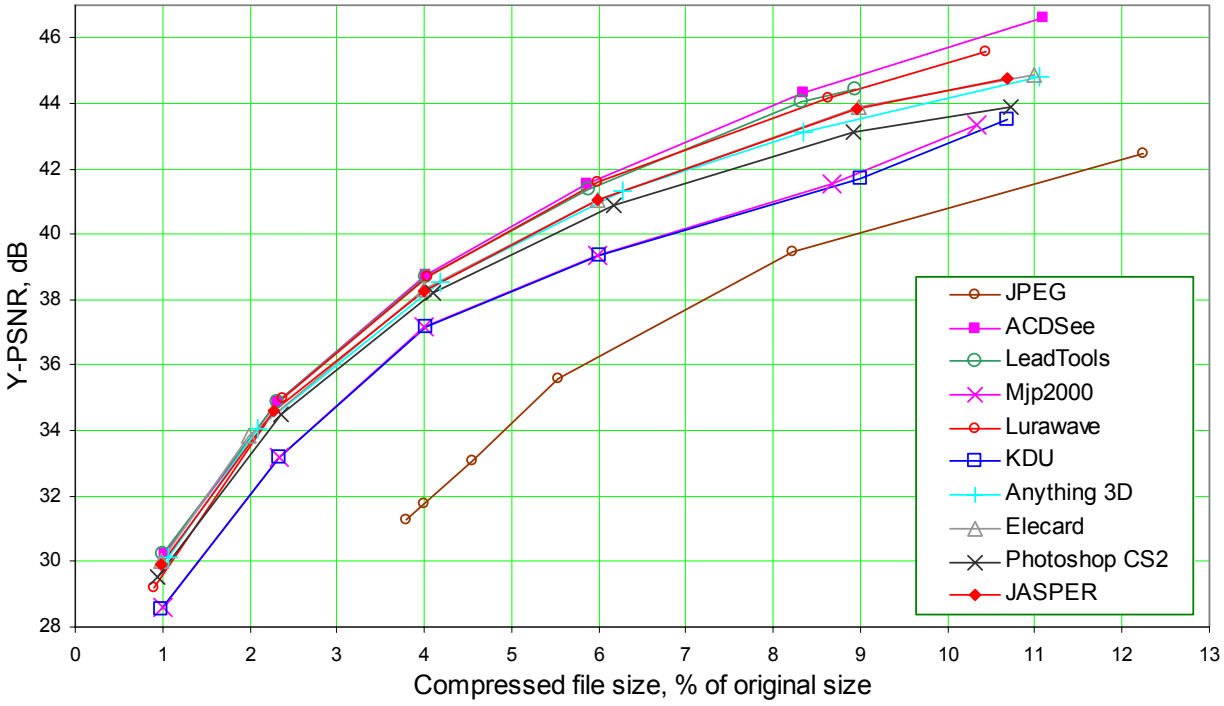


Picture 4. Delta-Y-PSNR, Lenna

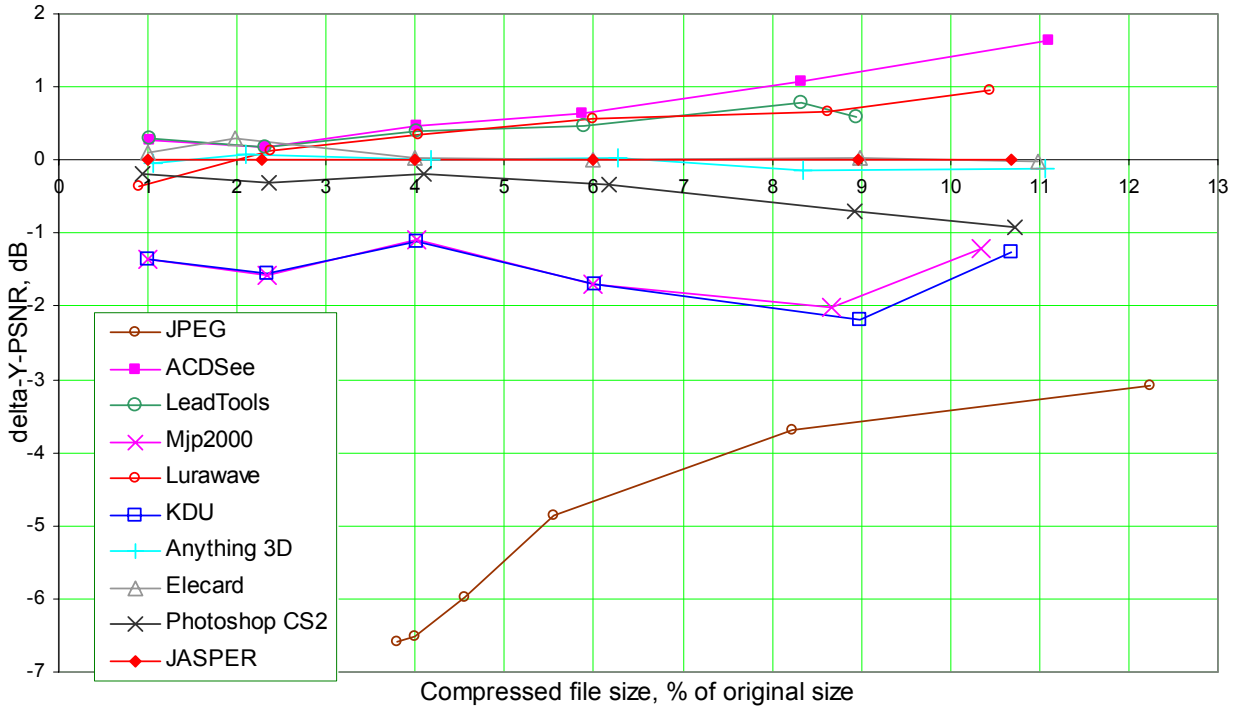
Conclusions:

- Most of the codecs perform better than the reference one (JASPER).
- It is hard to define a leader on high compression. ACDSee is the best on low compression rates.

Lighthouse image



Picture 5. Y-PSNR, Lighthouse

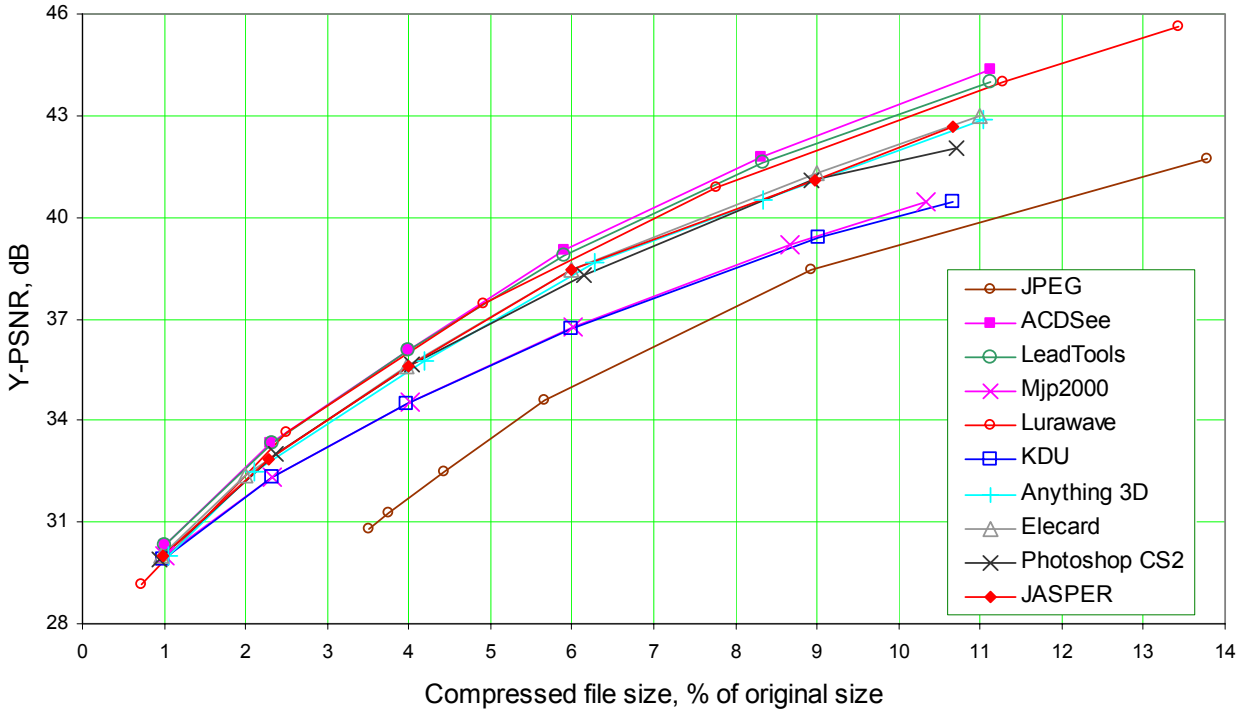


Picture 6. Delta-Y-PSNR, Lighthouse

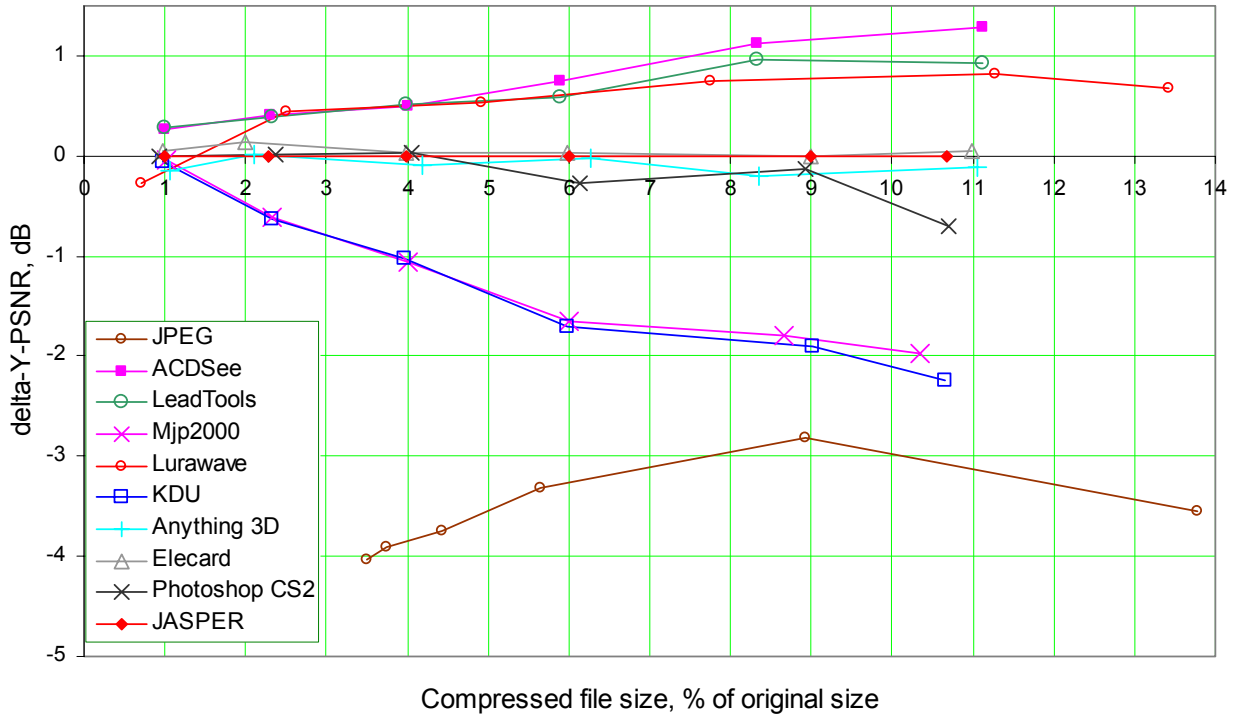
Conclusions:

- Three codecs have PSNR values lower than the reference one has.

House image



Picture 7. Y-PSNR, House



Picture 8. Delta-Y-PSNR, House

Conclusions:

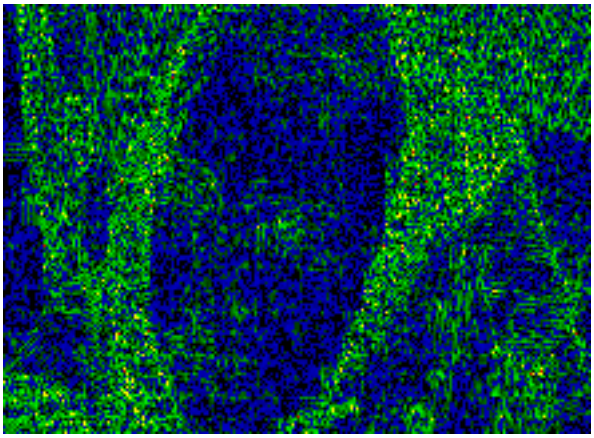
- On this image JPEG is not as far from JPEG 2000 as on the others – 1-3 dB below
- One can clearly determine two groups of codecs that have similar PSNR values: medium quality - Elecard, Photoshop, Anything 3D, Jasper; high quality - ACDSee, LeadTools and Lurawave.

Visual comparison

JPEG and JPEG 2000 visual comparison

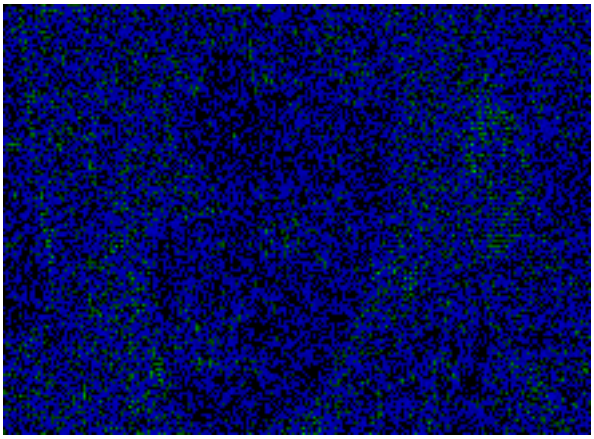
Difference in PSNR values between JPEG and JPEG 2000 codecs is so high that superiority of JPEG 2000 is obvious. On the following pictures this difference is maximal, size of image compressed by JPEG 2000 is 851 bytes less.

Barbara, JPEG, 31561 bytes



Difference between JPEG and original

Barbara, JPEG 2000, ACDSee, 32412 bytes



Difference between JPEG 2000 and original

JPEG 2000 codecs comparison

Difference in Y-PSNR values between JPEG 2000 codecs reaches 3 dB and can be easily seen. Many codecs turned out to have worse PSNR values than the reference codec (JASPER) has. The possible reason is that their authors were more interested in perfect visual quality but not in metric value.

This is 'Barbara' test image, compressed 50 times.

Jasper, 17974 bytes

Photoshop CS2, 18669 bytes

ACDSee, 18324 bytes

Lurawave, 17648 bytes

Morgan JPEG 2000, 18368 bytes

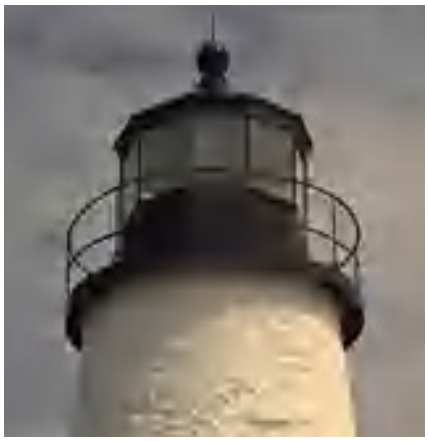
KDU_compress, 18402 bytes

Anything 3D, 16492 bytes

Leadtools, 18387 bytes

Elecard, 15611 bytes

With JPEG 2000 it is possible to operate at higher compression ratios than with JPEG. Following image ‘Lighthouse’ was compressed 100 times.



Jasper, 7811 bytes

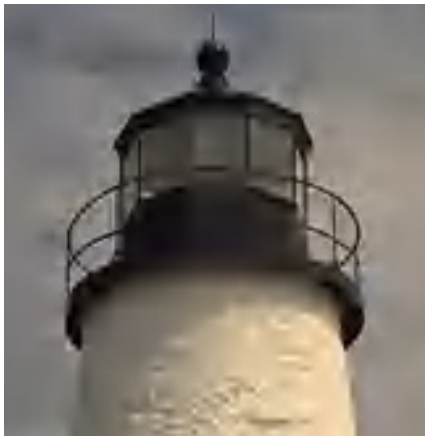
Photoshop CS2, 7372 bytes

ACDSee, 7989 bytes

Lurawave, 7016 bytes

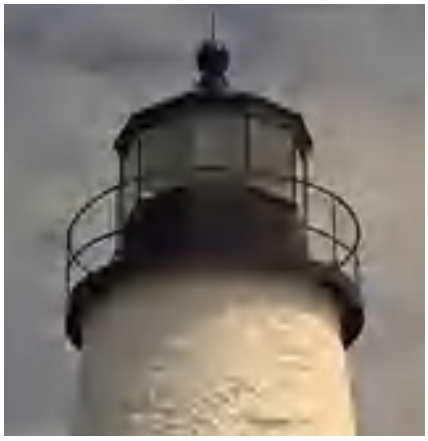
Morgan JPEG2000, 7864 bytes

KDU_compress, 7804 bytes



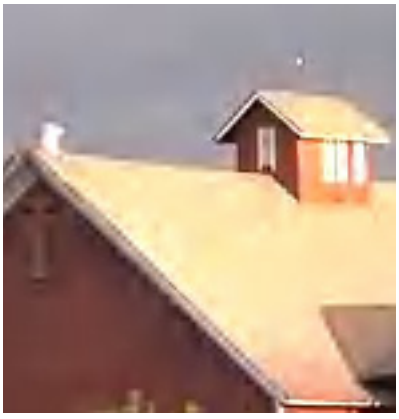
Anything 3D, 8349 bytes

Leadtools, 7942 bytes

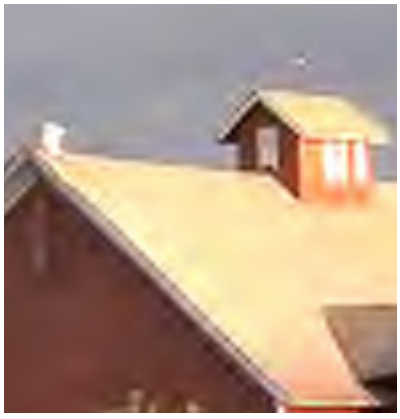


Elecard, 7815 bytes

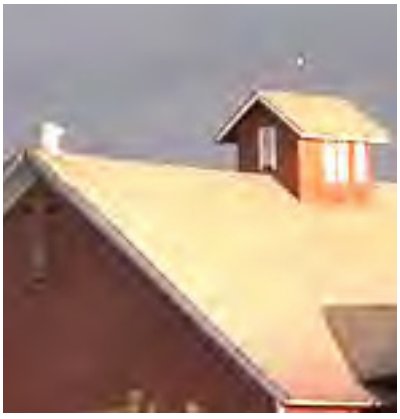
This is a part of test image ‘House’, compressed 100 times.



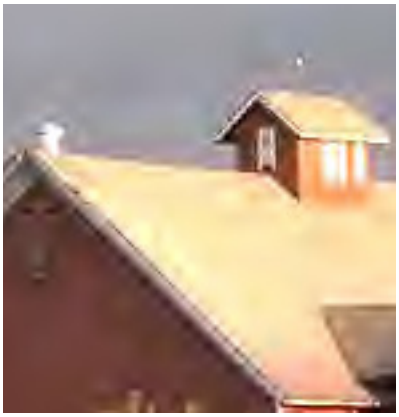
Jasper, 7809 bytes



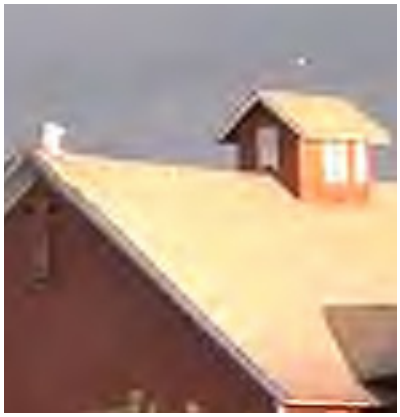
Photoshop CS2, 7363 bytes



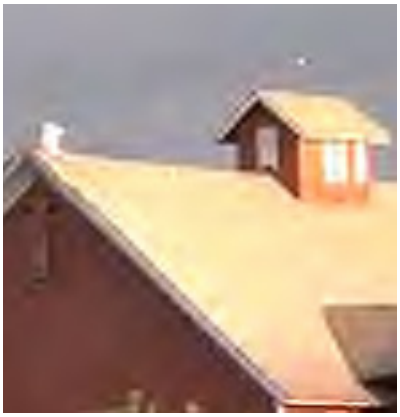
ACDSee, 7925 bytes



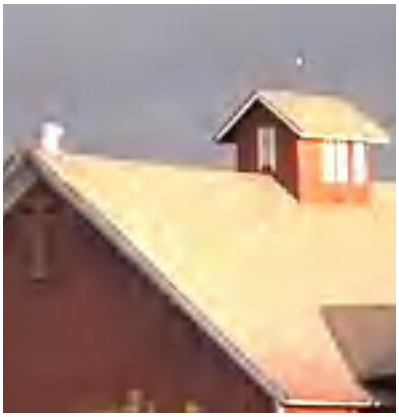
Lurawave, 5651 bytes



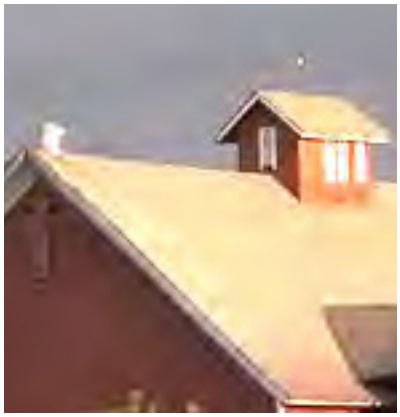
Morgan JPEG2000, 7938 bytes



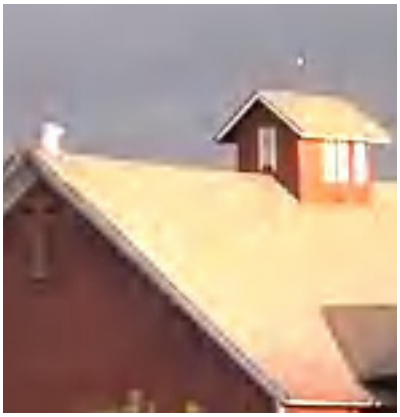
KDU_compress, 7682 bytes



Anything 3D, 8337 bytes

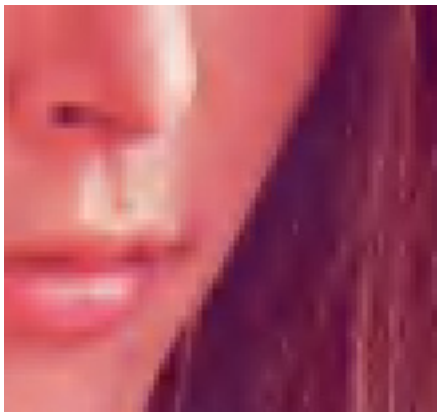


Leadtools, 7919 bytes

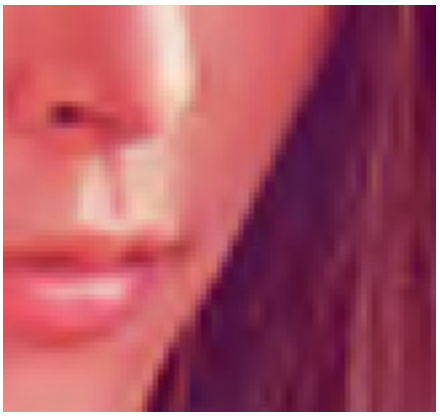


Elecard, 7664 bytes

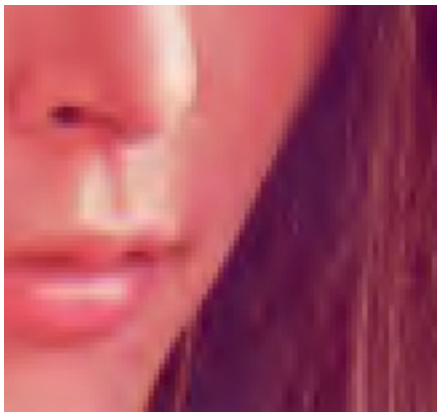
This is a part of test image ‘Lenna’, compressed 100 times. Fragment is two times enlarged.



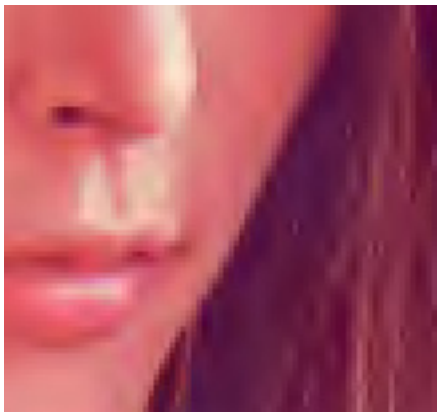
Jasper, 17983 bytes



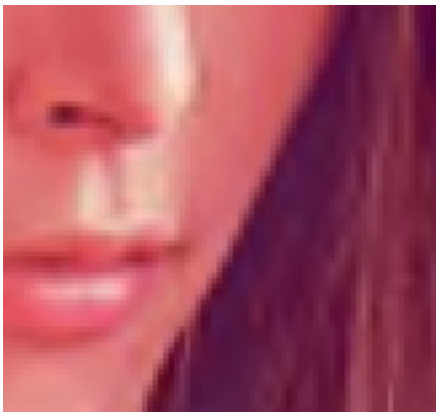
Photoshop CS2, 18642 bytes



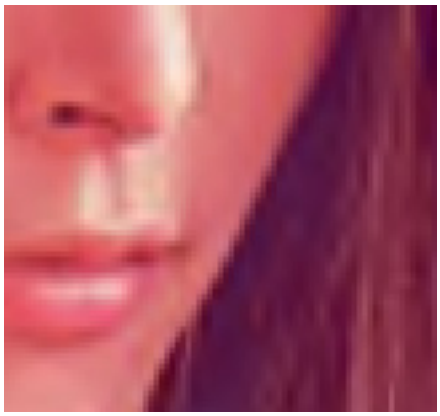
ACDSee, 18291 bytes



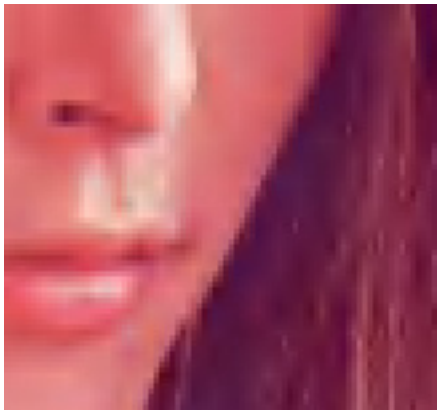
Lurawave, 14038 bytes



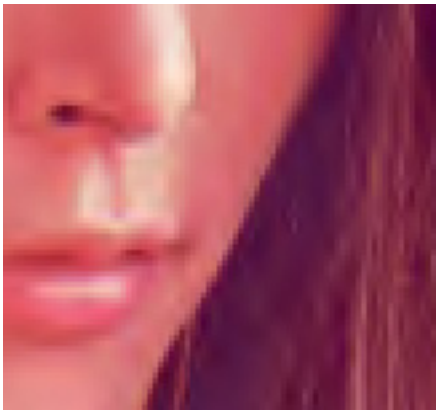
Morgan JPEG2000, 18285 bytes



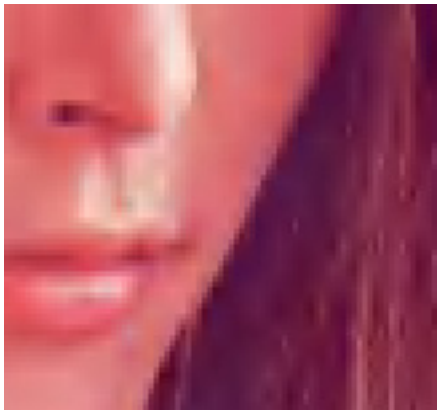
KDU_compress, 18395 bytes



Anything 3D, 16507 bytes



Leadtools, 18403 bytes



Elecard, 15677 bytes

Visual comparison conclusions

As one can see on images above, visual quality of compressed image does not always corresponds to it's PSNR value. For instance, there are many aliasing artifacts on image "Barbara" compressed by codec from Photoshop CS2, they arise on all stripes on headscarf and on pants. Although face on the image compressed by codec Jasper is slightly worse than on the image compressed by Photoshop CS2, overall image quality of Jasper is better. Despite this, Jasper has lower PSNR values.

In our opinion, ACDSee codec has the best visual quality on this test set. It has best PSNR values as well. Leadtools, Lurawave, Elecard and Anything 3D perform quite close to the ACDSee.

Informal codecs comparison

As one can see on Y-PSNR diagrams codecs behave differently on different images and compression factors, so to understand the situation on the whole test set we suggested an informal estimation where every codec is given some score depending on the results of its measurement.

Informal comparison rules

- JPEG 2000 codecs are compared.
- If some codec is stably better than all the others it is given score 4 regardless of other results.
- If some codec is worse than all the others in more than one point it is given score 1 regardless of other results.
- Otherwise if codec is better than the reference one in more than one point it is given score 3.
- Otherwise it is given score 2.

Informal comparison results

Codec	Barbara	Lenna	Lighthouse	House	Total	Place
JASPER	2	1	2	2	7	8
ACDSee	4	4	4	4	16	1
Leadtools JPEG 2000 Photoshop plugin	3	3	3	4	13	3
Morgan JPEG 2000 toolbox	2	3	2	2	9	5,6
Lurawave	4	3	3	4	14	2
Kdu_compress	1	3	1	1	6	9
JPEG 2000 Compressor (Anything 3D)	3	1	3	2	9	5,6
Elecard Wavelet	3	2	3	3	11	4
Photoshop CS2 ‘native’ plugin	3	1	2	2	8	7

General conclusions

- Different implementations of JPEG 2000 standard have different compression quality, especially on high compression. This difference can be visually seen.
- Despite the fact that this standard was accepted quite recently many manufacturers managed to achieve major quality improvements in comparison with basic implementation.
- All JPEG 2000 codecs perform much better than codecs of JPEG standard. If JPEG 2000 support is added to popular programs (browsers, viewers, image editors, etc.) it will be able to completely replace outdated JPEG.

Gratitude

Authors want to thank Alexander Parshin for help in verifying and preparing this comparison.

About us (Graphics & Media Lab Video Group)

Graphics & Media Lab Video Group is a part of Graphics & Media Lab of Computer Science Department in Moscow State University. The history of Graphics Group began at the end of 1980's. Graphics & Media Lab was officially founded in 1998. Main research directions of the lab lie in different areas of Computer Graphics, Computer Vision and Media Processing (audio, image and video processing). Some of research results were patented, other results were presented in a number of publications.

Main research directions of Graphics & Media Lab Video Group are video processing (pre-, post- and video analysis filters) and video compression (codecs' testing and tuning, quality metrics research, development of codecs).

Our main achievements in **video processing:**

- High quality industrial filters for format conversion including high quality deinterlacing, high quality frame rate conversion, new fast practical super resolution, etc.
- Methods for modern TV-sets: big family of up-sampling methods, smart brightness and contrast control, smart sharpening, etc.
- Artifacts' removal methods: family of denoising methods, flicking removal, video stabilization with frame edges restoration, scratches, spots, drop-outs removal, etc.
- Specific methods like: subtitles removal, construction of panorama image from video, video to high quality photo, video watermarking, video segmentation, practical fast video deblur, etc.

Our main achievements in **video compression:**

- Well-known public comparisons of JPEG, JPEG-2000, MPEG-2 decoders, MPEG-4 and annual H.264 codec's testing; also we provide tests for "weak and strong points of codec X" for companies with bugreports and codec tuning recommendations.
- Our own video quality metrics research, public part is MSU Video Quality Measurement Tool and MSU Perceptual Video Quality Tool.
- We have internal research and contracts on modern video compression and publish our MSU Lossless Video Codec and MSU Screen Capture Video Codec – codecs with ones of the highest compression ratios.

We are really glad to work many years with companies like Intel, Samsung, RealNetworks and others.

A mutual collaboration in areas of video processing and video compression is always interesting for us.
E-mail: video@graphics.cs.msu.ru

MSU Video Quality Measurement Tool

MSU Graphics & Media Lab. Video Group.

GRAPHICS & MEDIA LAB VIDEO GROUP

Main Features

1. 12 Objective Metric + 5 Plugins

PSNR several versions,
MSAD,
Delta,
MSE,
SSIM Fast,
SSIM Precise,
VQM,
MSU Blurring Metric,
MSU Brightness Flicking Metric,
MSU Brightness Independent PSNR,
MSU Drop Frame Metric,
MSU Noise Estimation Metric,
MSU Scene Change Detector,
MSU Blocking Metric.

2. More Than 30 Supported Formats, Extended Color Depth Support

*.AVI,
*. YUV:
YUV,
YV12,
IYUV,
UYVY,
Y,
YUY2,
*.BMP,
*.AVS:
*.MOV,
*.VOB,
*.WMV,
*.MP4,
*.MPG,
*.MKV,
*.FLV,
etc.,

Extended Color Depth:
P010, P014,
P016, P210,
P214, P216,
P410, P414,
P416,
P410_RGB,
P414_RGB,
P416_RGB.

3. Multi-core Processors Support

MMX, SSE and OpenMP Optimizations

4. Comparative Analysis

Comparison of 3 files at a time

5. ROI Support

Metric calculation for ROI (Region of Interest)

6. GUI & Batch Processing

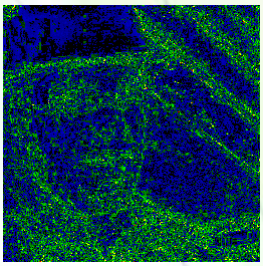
GUI and command line tools

7. Plugins Interface

You can easily develop your own metric

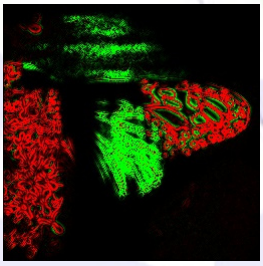
Visualization Examples

Allows easily detect where codec/filter fails

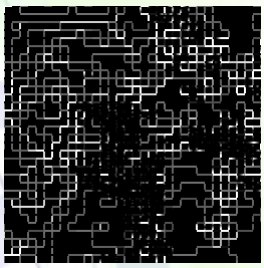


Y-YUV PSNR

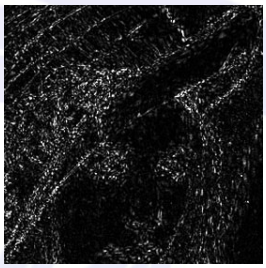
Y-YUV Delta



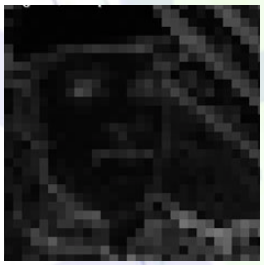
MSU Blurring Metric



MSU Blocking Metric



Y-YUV MSE



VQM

8. Universal Format of Results

Results are saved in *.csv files

9. HDTV Support

10. Open-Source Plugins Available

11. Metric Visualization

Fast problem analysis, see examples above.

http://www.compression.ru/video/quality_measure/index_en.html

Tool was downloaded more than 100 000 times!

Free and Professional versions are available

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