JPEG 2000 for digital preservation

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Presentation themes

JPEG 2000 is now an accepted and viable format for digital preservation. However there are still issues and mis-understandings concerning its application:

- **'Lossless' -what does this mean in the context of digital preservation.**
- **'Quality' and its assessment**
- **JPEG 2000 is an architecture and a family....**
- **Relationship to other standards**
- **How to handle colour management**
- **Metadata - extraction and inclusion**
- **JPEG 2000 in practice**

Use of JPEG 2000 - where to look

Who's using JPEG 2000?

- **Libraries and museums (especially maps and newspapers)**
  - **British Library, Library of Congress, Harvard, Princeton, Yale, UK and US National Archives, + key institutions in Canada, Australia, Japan, New Zealand etc.**
  - *See http://www.collectionscanada.gc.ca/digital-initiatives/012018-2100.03-e.html for a fuller listing and links*
- **DAM vendors**
  - **Luna (“Insight”), DiMeMa (“ContentDM”), Ex Libris (“Digitool”) ,**
- **Major sector initiatives**
  - **Digital Cinema**
  - **Geospatial mark-up**
  - **Medical imaging**
  - **Identity - fingerprints, facial recognition**
- **Code options**
  - **Open source: OpenJPEG, Jasper**
  - **Closed: Aware, Luratech, LeadTools, Pegasus, Kakadu, Adobe etc**

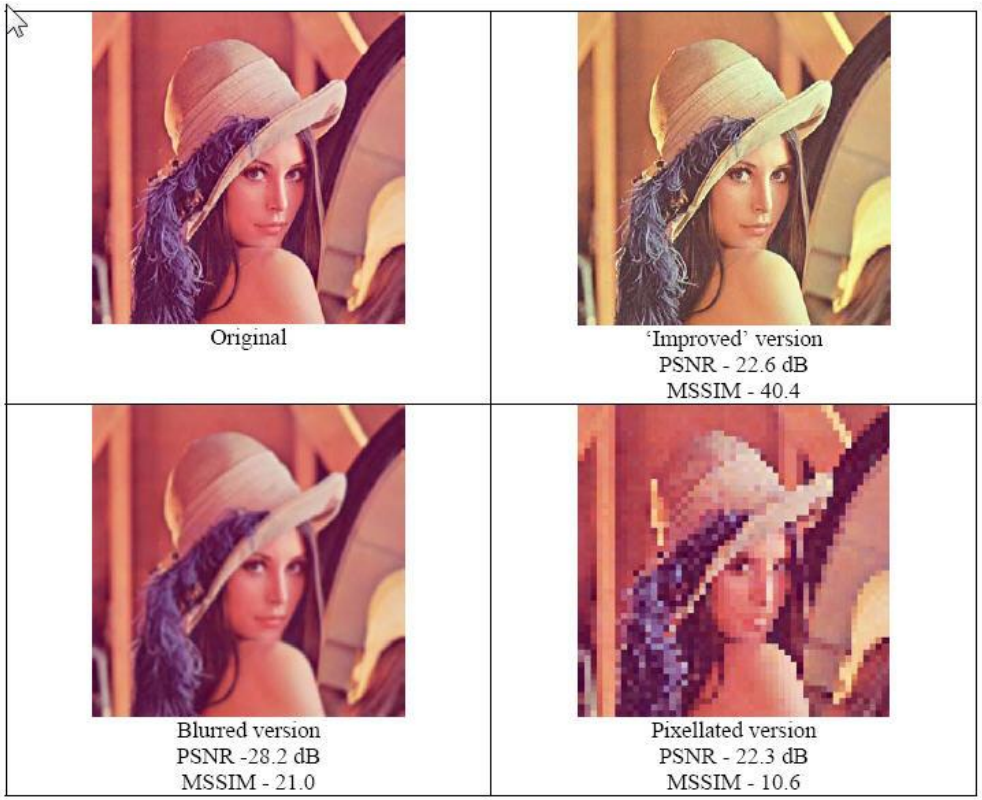
What does 'lossless' mean?

- Often used to referred to just the digital image as captured (and not necessarily at an optimal resolution or bit depth!)
- Tendency to ignore colour space as an issue - assumption that AdobeRGB is 'better' than sRGB because it can handle more colour gamut (ignoring bit depth quantisation, and wider gamut spaces)
- Metadata is often discarded, or separated from the original image, irrespective of its intent or potential usage. In addition, as metadata is updated, some metadata in the image format is ignored, leading to potential conflicts or discrepancies
- Lossless conversion should attempt to preserve all of the above!
- JPEG 2000 is not optimal for basic lossless image compression (neither is PNG or JPEG-LS - they all have their place)

Quality measures - what's wrong with PSNR?

Currently - PSNR still seen as accurate measure of quality.

It isn't - its a measure of how closely the reconstituted image matches the original. However it does not take into account human perception. For example....

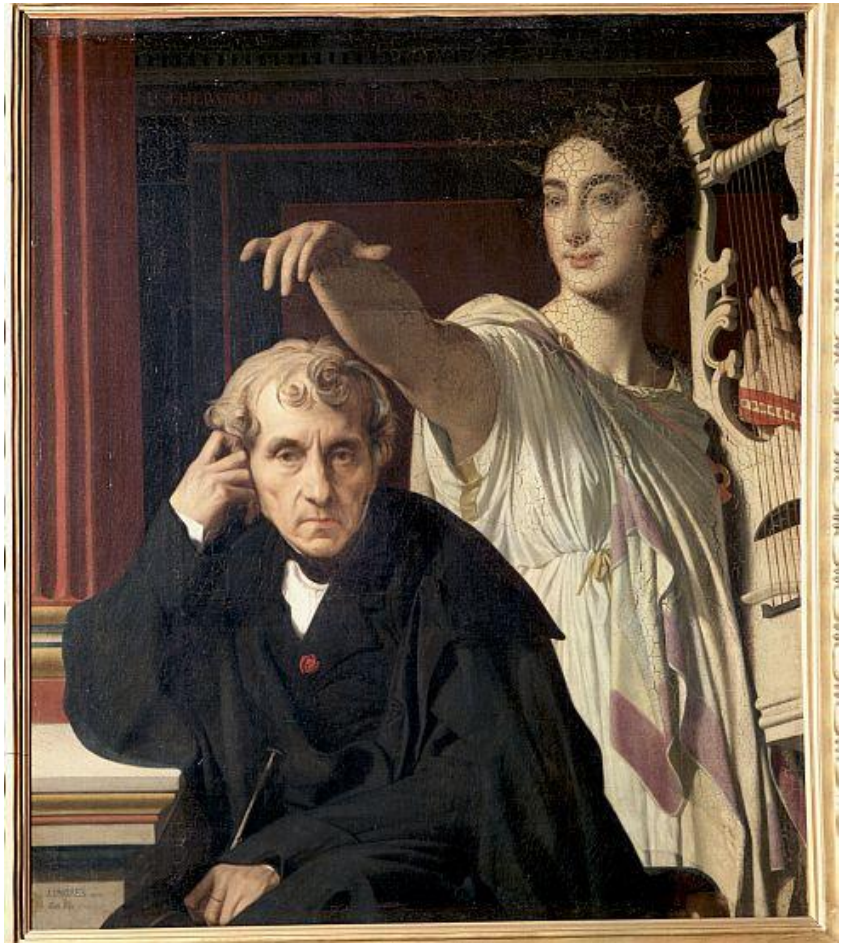


Images have similar PSNR - the top right image has been adjusted for improved colorimetry and sharpness. The blurred image is 'best' on a PSNR basis!

PSNR remains in common use as the metric which is used to adjust a lossy compression process, without regard to content and intent.

This also leads to incorrect assumption about what is an optimum compression rate....

Test image



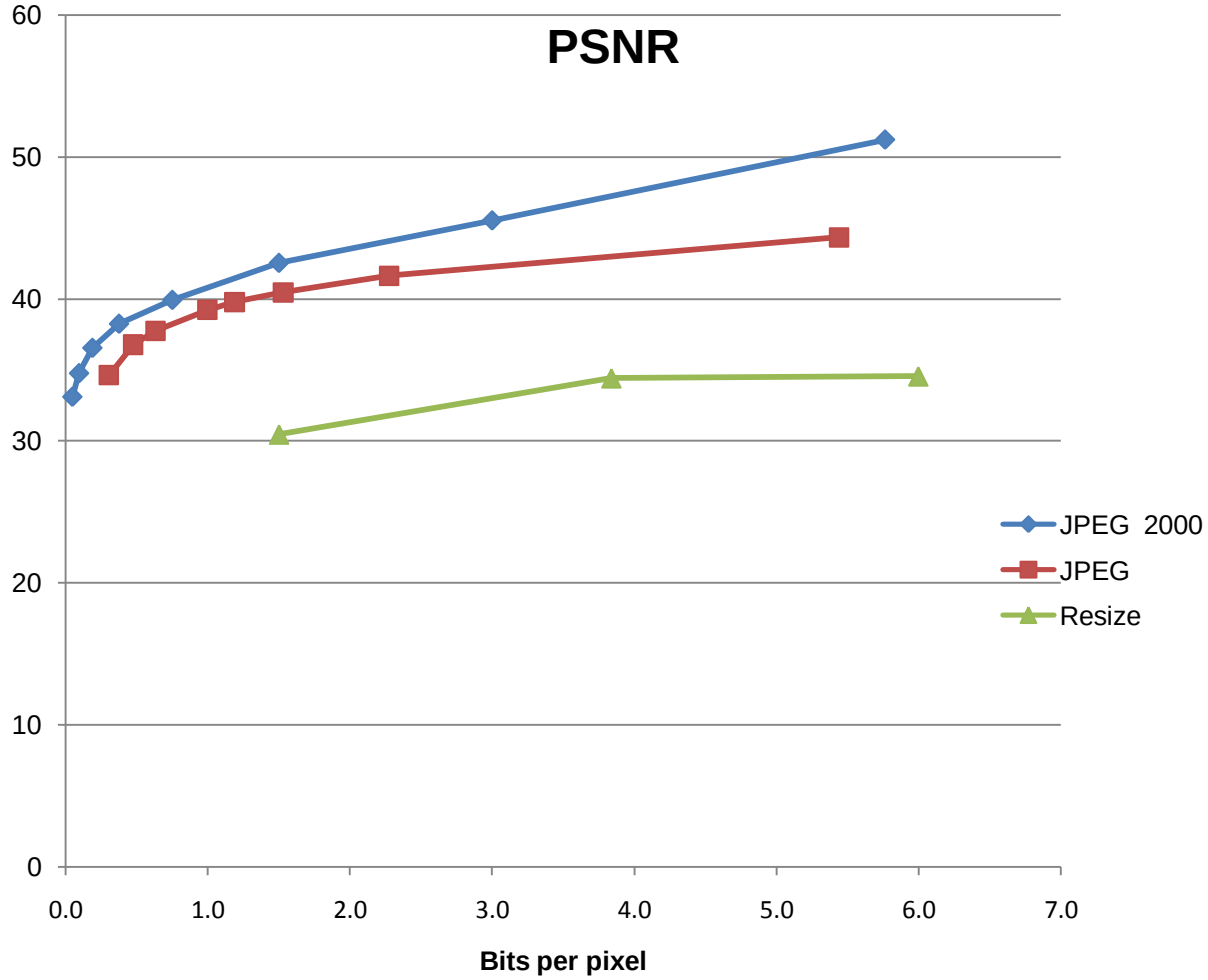
Test image, from an original in the Louvre, "Cherubini and the Muse of Lyrical Poetry", by Jean Ingres. Typical of a damaged exhibit, captured prior to potential restoration.

Available as 8 or 16 bit . The tests use the 8 bit version :
- 56 Mbytes as a TIFF
- 4088 x 4608 pixels

Three different compression options :

- JPEG 2000 compressed using Kakadu with typical values
- JPEG compressed, using IJG codec
- downsized by different factors, then resized to original using Lanczos extrapolation with sharpening (emulates using scanning resolution to determine file size)

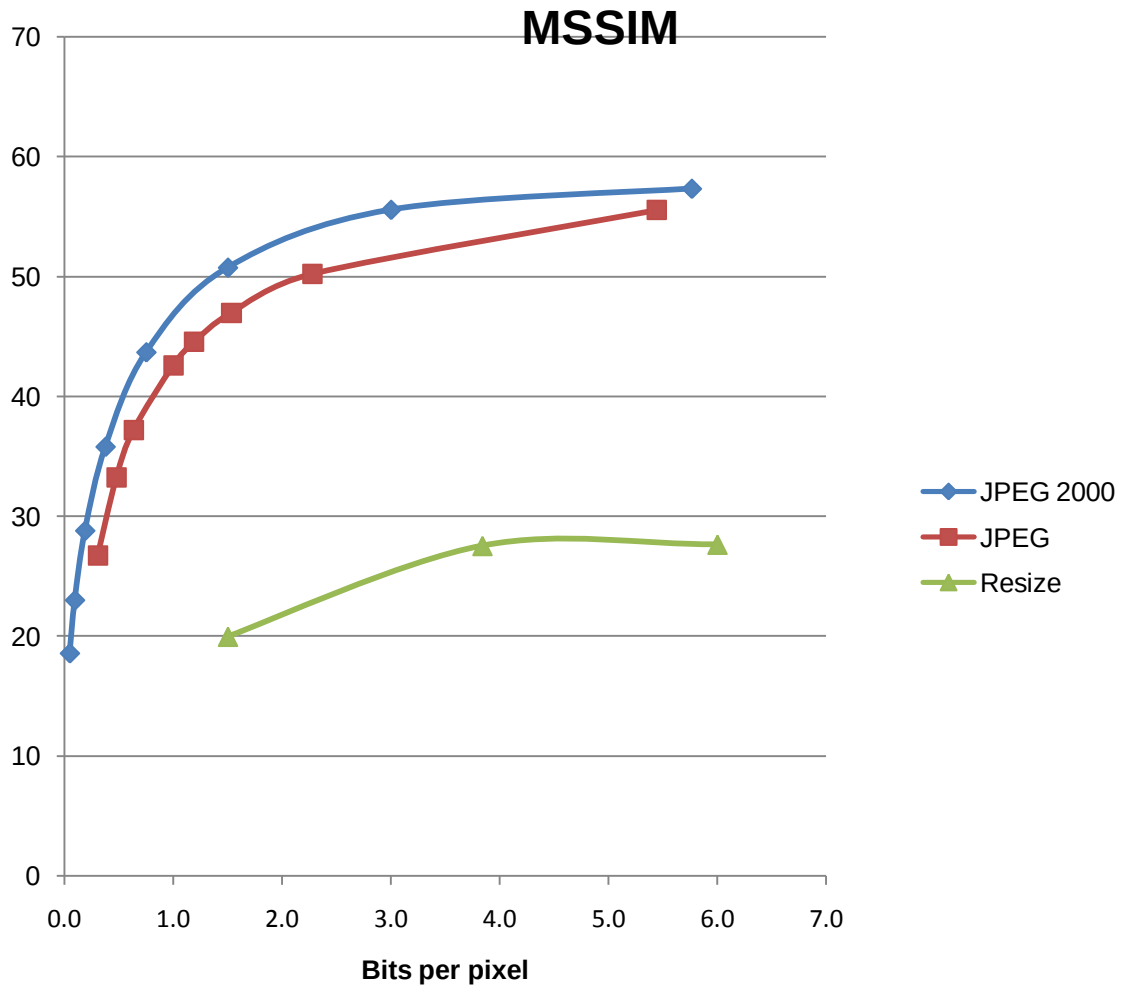
PSNR measurements



Using PSNR as a measure, we see that JPEG 2000 is significantly 'better' than JPEG , with the most improvement from c. 1.5 bits per pixel onwards.

Both are a lot 'better' than the up-sampled image, showing that 'lossy' compression at a higher scan resolution beats lossless compression at a lower scan resolution, easily.

MSSIM measurements



Using MSSIM as a measure, the curves are very different, and closer to a human perceptual response.
They show that there is little difference in visual terms between JPEG and JPEG 2000 at low compression ratios, also that you really need to reach around 3 bits per pixel to get a optimal trade-off in compression.

They also show how much better these lossy compression techniques are when used with 'over-sampled' data!

MSSIM is a derivative of the original SSIM proposals from Zhou Wang, created by Thomas Richter, University of Stuttgart and JPEG committee.

Quality metrics - suggestion

- **Sample at highest rate and bit depth available (as long as scanner noise, and other physical issues (vibration, lighting etc) do not come into play.**
- **Use JPEG 2000 at compression ratios of 8:1 or less to achieve optimal file size**

  (note most tests by institutions expressing concern about JPEG 2000 artefacts use ratios of 10:1 or 12:1 - see the MSSIM graph for why this is bad...)
- **Take advantage of the JPEG 2000 architecture and coding to allow for simple 'on the fly' re-purposing of the source data**
- **Use an appropriate colour space. sRGB if you are using 8 bit per component, or ProPhoto (ROMM RGB) for 16 bit, or conversion from camera RAW**
- **Make sure you capture, keep (and can read!) the metadata...**
- **and JPEG 2000 does do fully lossless, whatever you read elsewhere**

  Best non-image aware lossless compression of original TIFF

  (PAQ) 2.26:1 (after 1 hour for this file!) ZIP - 1.27:1 BZ2 - 1.65:1

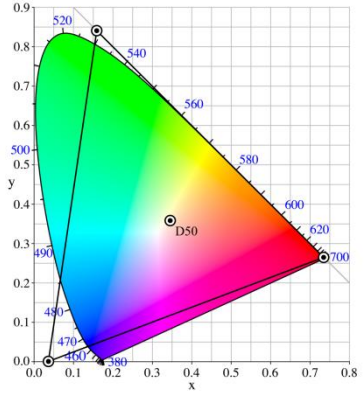
  Image-aware lossless compression

  JPEG-LS - 2.53:1 PNG - 2.20:1 JPEG 2000 - 2.48:1 STUFFIT - 2.84:1

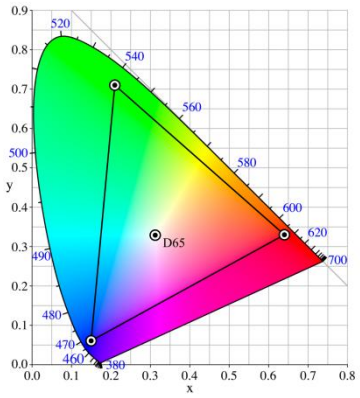
Colour management

Selection of a colour space (and support for it in the file format) is an important factor in preservation. JPEG 2000 provides for both enumerated colour spaces (sRGB, but not as yet Adobe RGB) , and complete ICC profiles (restricted to 3 components for the simpler JP2 file format).

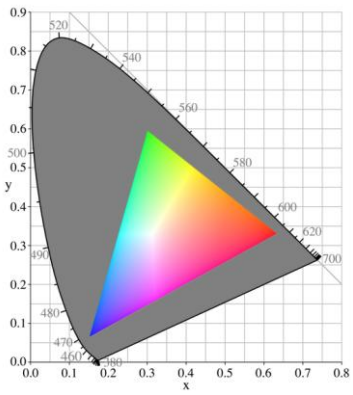
However bit depth is also a factor - the fewer the bits, the smaller the colour space that can be rendered without quantisation errors...



ProPhoto (ROMM RGB)



Adobe RGB 1998



sRGB

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Metadata - extraction and inclusion

JPEG 2000 provides for a wide variety of metadata to be included in the file format.

The simpler file format defined in part 1 (.JP2) offers

- **XML metadata (well-formed)**
- **UUID based for binary data, both as defined by JPEG (eg jp2i for IPR) and for third parties - e.g. EXIF, IPTC, XMP and so on(they can of course also include XML metadata).**

  A good listing is available as part of the excellent 'EXIFTool' program at http://sno.phy.queensu.ca/~phil/exiftool/TagNames/Jpeg2000.html

The more complicated file format (.JPF or .JPX, according to vendor) adds defined XML schema, for example based on the DIG35 proposals from I3A, and a more comprehensive set of tags (e.g. adding full support for ICC profiles).

However there are many alternatives, all of which may be present..... (Z39.87(MIX), METS, GML etc)

JPEG 2000 in practice

Potential issues / considerations

- **Not all encoders are equal - vary in quality, speed, ability to parameterise, memory usage, cost, stability, CPU usage etc**

  Photoshop support relatively poor at present, for example

- **Transcoding capabilities vary - ability to (e.g.) read TIFF files (especially handling colour space and ICC profile), metadata (and encapsulate same)**
- **Much more to the standard than just basic still image compression - practical tools just starting to exist, but not all full implementations - MJP2, JPSEC, JPWL, JPIP etc.**
- **Other technologies that can be used with JPEG 2000 - even as alternatives to the standard - e.g. IIPImage, Photosynth instead of JPIP**

  Excellent example of this at Moravian Library Old Maps project, [20] http://help.oldmapsonline.org/jpeg2000, using a variety of viewers

- **Other technologies being developed within MPEG/JPEG - MPEG 7 visual search with image signatures, JPSearch**
- **Other technologies may offer better performance for pure lossless - remember JPEG 2000 designed to be flexible, and an architecture - beware of false or insufficient comaprisons**
- **Unlikely to be well implemented in cameras or web browsers.... (*opinion!*)**