JPEG and JPEG 2000

Past, present, and future

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Planned presentation

❖ Brief introduction

❖ JPEG – 25 years of standards…

❖ Shortfalls and issues

❖ Why JPEG 2000?

❖ JPEG 2000 – imaging architecture

❖ JPEG 2000 – what it is (should be!)

❖ Current activities

❖ New and continuing work…

Introductions

Richard Clark

- Working in technical standardisation since early 70's
- Fax, email, character coding (8859-1 is basis of HTML), image coding, multimedia
- Elysium, set up in '91 as SME innovator on the Web
- Currently looks after JPEG web site, historical archive, some PR, some standards as editor (extensions to JPEG, JPEG-LS, MIME type RFC and software reference for JPEG 2000), HD Photo in JPEG, and the UK MPEG and JPEG committees
- Plus some work that is actually funded…….

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Elysium in Europe

❖ ACTS project

- – SPEAR – advanced JPEG tools

❖ ESPRIT project

- – Eurostill – consensus building on JPEG 2000

❖ IST

- – Migrator 2000 – tool migration and feature exploitation of JPEG 2000
- – 2KAN – JPEG 2000 advanced networking

❖ Plus some other involvement through CEN in cultural heritage and medical imaging, Interreg and others

25 years of standards

- ❖ JPEG – Joint Photographic Experts Group, joint venture between ISO and CCITT (now ITU-T)
- ❖ Evolved from photo-videotex, character coding
- ❖ First meeting March 83 – JPEG proper started in July 86. 42nd meeting in Lausanne, next week…
- ❖ Attendance through national standards bodies, liaison organisations, personal invitation
- ❖ Size has varied from 8 to 100+. Normally 60+ attend
- ❖ Meets three times a year for a week – Europe, North America and Australasia
- ❖ Outputs mostly joint ISO Standards / ITU Recommendations – however some documents just ISO, or even just ITU-T
- ❖ Unpaid, no corporate entity, no branding, no consortium

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Issues in standardisation

❖ First IT standard?

    – Facsimile in 1843 is a contender

    – Alexander Bain then went on to demonstrate a paper tape controlling a set of musical pipes

    – However….

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Issues in standardisation

❖ First IT standard?

    – However patents have been a problem for 293 years so far…

    – in 1714, in patent 385 in the UK, Henry Mill affirmed that he had:

"..by his great study, pains and expense, lately invented and bought to perfection an artificial machine or method for the impressing or transcribing of letters, singly or progressively one after the other, as in writing, whereby all writings whatsoever may be engrossed on paper or parchment so neat and exact as not to be distinguished from print .. the impression being deeper and more lasting than any other writing, and not to be erased or counterfeited without manifest discovery".

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Advantages of standardisation

❖ Consolidate many different approaches
  – First formal standard from BSI reduced number of tramrail variants from 75 to 5, saving £1 million per annum

❖ Market creation
  – In case of MPEG (digital TV, DVD etc), no one company could have invested enough to create market (e.g MJ2…)

❖ Create uniformity and some user credibility
  – 'JPEG' and 'MP3' are terms which are recognised universally

❖ Longevity
  – in IT terms character coding and JPEG imaging life far exceeds that of the technology they are used on

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Problems in standardisation

❖ Intellectual 'property'
  – In the case of standards this means patents, and is defined at national level, and for software can be (very, in Europe) contentious (thousands possibly for JPEG 2000!)
  – 'Reasonable and non-discriminatory' usage
  – Can be 'found' many years later – viz Forgent / Philips for JPEG
  – Ownership and attitudes can change
❖ Increasing complexity
  – Problems in definition, correction, interpretation and implementation
❖ Over-implementation
  – 'Feature creep' - e.g. browsers, RAW files for de facto issues
❖ De facto and de jure implementation.
❖ Must be supported by everyone - patent issues…
❖ Choice and market share

JPEG

❖ It's a committee, not a standard!

❖ Currently four families of standards - basically toolkits for technicians

❖ 'JPEG' standard is basically sub-minimal implementation of some bits of a toolkit, together with an ad hoc file format

❖ Original work to support IBM PC AT on ISDN

❖ What is 'lossy' / 'lossless' ?

❖ Can it be improved (T.851, Stuffit)?

❖ Changes in environment

– need for metadata, RAW files, rights management, extended and managed colour spaces, 16 bit (only 8/12 in original except lossless), large images

– PCs are a little more powerful these days too

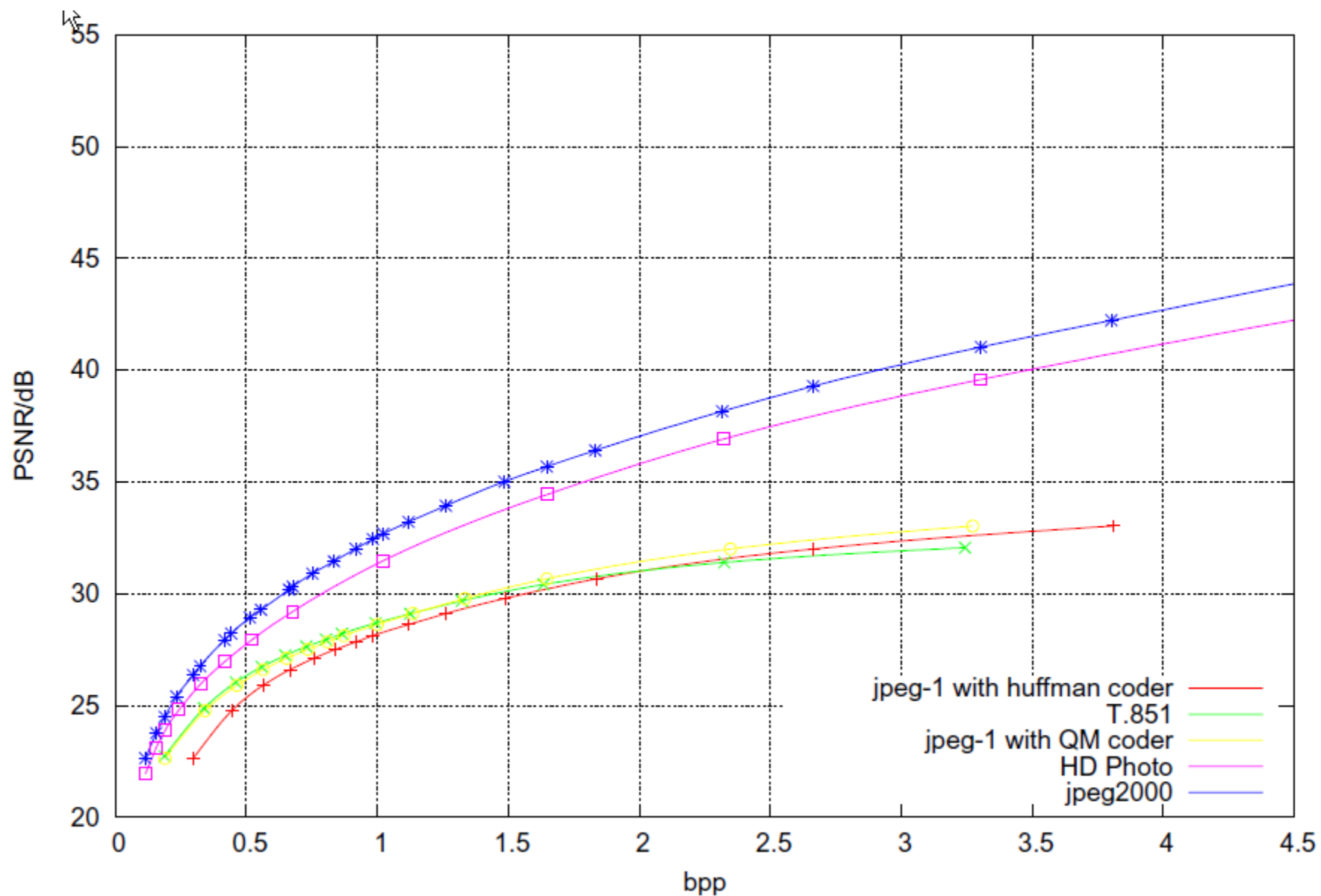– Network, display and storage devices

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JPEG 2000

❖ Can all these extra features be put together neatly?
❖ Multiple parts -
  – Baseline (IP very important)
  – Extensions (XML in files plus some (patented?) options)
  – Motion JPEG 2000 - Digital Cinema Initiative
  – Conformance - make sure it works!
  – Reference software
  – Hybrid coding (much better for document scanners)
  – JPSEC - encryption and security
  – JPIP - remote delivery
  – JP3D - 3D imaging
  – JPWL - wireless
  – File format - common with MPEG4 (Quicktime) - MAF players
  – Baseline encoder (eg for digital camera)
  – XML handling

JPEG 2000 features

- ❖ Better compression, and smooth transmission from lossy to lossless
- ❖ Proper colour handling, metadata in file format
- ❖ Progressive transmission
  - – can reorder, for example to prioritise resolution or accuracy
  - – can truncate image stream – no need for multiple versions
  - – can be delivered resiliently
  - – can be delivered selectively, and securely
- ❖ Regions of interest can be coded separately, and differently
- ❖ Use in compound documents with other compression schemes
- ❖ Rights protection through partial encryption
- ❖ Flexible file format

How to compare techniques?

❖ Lossy or lossless (really lossless - bit depth, colour space, metadata?)

❖ Other issues than compression - ability to handle range of features offered by JPEG 2000

❖ Nature of errors - is SNR a valid measure?

❖ How well does it match current technology?

❖ Longevity - Domesday project…
  – "Let's not decry Domesday as a waste of time and money. It is a salutary lesson in technology creep and we need to know how to cope with it in future. Watch this space!"

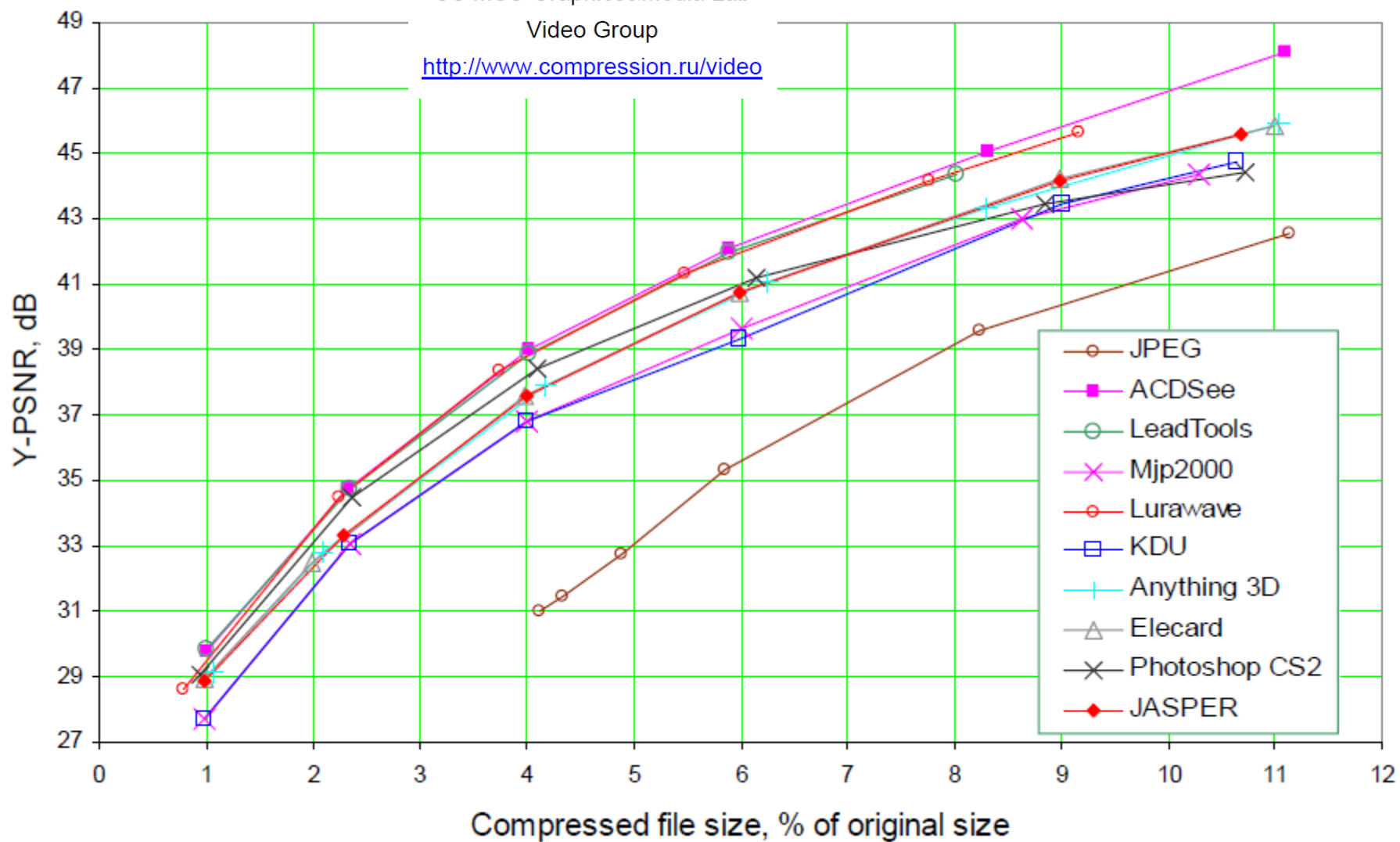❖ Pragmatics rather than semantics

❖ And for some practical comparisons…….

PSNR/dB vs bpp

Legend:
- jpeg-1 with huffman coder
- T.851
- jpeg-1 with QM coder
- HD Photo
- jpeg2000

Barbara image

September 2005
CS MSU Graphics&Media Lab
Video Group
http://www.compression.ru/video

Y-PSNR, dB

Compressed file size, % of original size

Legend:
- JPEG
- ACDSee
- LeadTools
- Mjp2000
- Lurawave
- KDU
- Anything 3D
- Elecard
- Photoshop CS2
- JASPER

Compression ratio (RGB)

Y-axis: **Compression ratio |**
Values: 1.00, 1.50, 2.00, 2.50, 3.00, 3.50

X-axis: **Sequence**
bankomatdi, battle, bbc3di, bus, foreman, helicopterdi, NDDP7di, susidi, tensdi

Legend:
- LEAD JPEG v1.0.0.1
- CamStudio GZIP(9) v1.0
- HuffYUV 2.1.1(predict left/no decorr.)
- HuffYUV 2.1.1(predict left)
- HuffYUV 2.1.1(predict gradient)
- Pegasus PicVideo JPEG v.2.10.0.29
- AVIzlib(hi compression) v2.2.3
- Lagarith v1.0.0.1
- LOCO v0.2
- MindVid v1.0 beta 1
- FFV1 ffdshow 08/08/04
- MSUlab beta v0.2.4
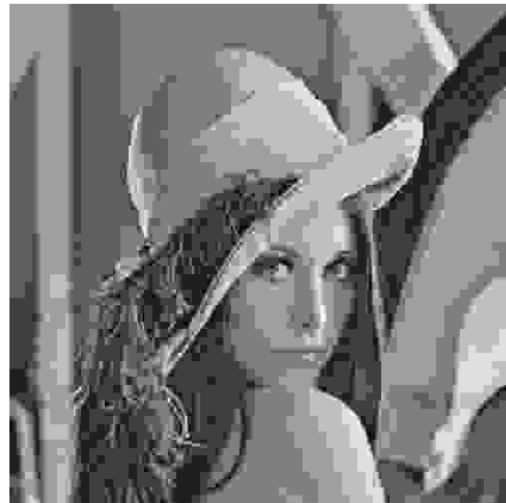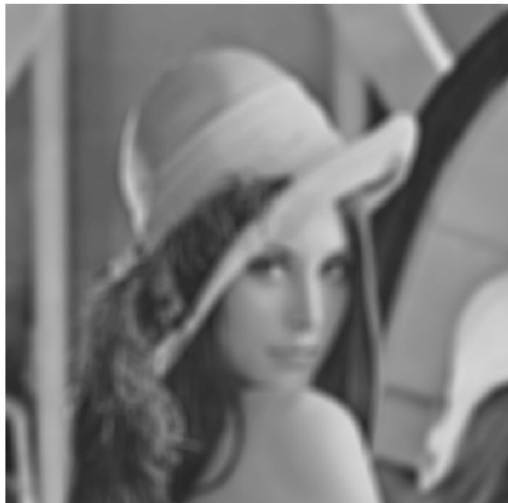- Alpary v2.0
- CorePNG v0.8.2
- MSUlab v0.5.2

(a)

(b)

From Zhou Wang

Universal image quality index

All images have same mean square error….

(a) is the original!

Need to get the metrics right.

States in creating a JPEG standard

❖ Initial proposal for new work item, or to split an existing item - requires 5 national bodies to support

❖ Minimum time for each is usually every meeting cycle (4 months), more often 2 cycles in working stages

❖ Call for Proposals (CFP)

❖ Working Draft (WD) - normally 3-6 months, can be longer if multiple iterations

❖ Committee Draft (CD)

❖ Final Committee Draft (FCD) - out for sub-committee vote

❖ Final Draft International Standard (FDIS) - out for general vote

❖ International Standard (IS) - published (can be 1+ year!)

JPEG 2000 Part 1
Core coding system

❖ Published 2004 ISO (CHF244) or 2002 by ITU-T T.800 (free d/l)

  – http://www.itu.int/rec/T-REC-T/en

❖ 4 corrigenda and 2 amendments (primarily for Digital Cinema)

❖ Intended as royalty and license fee free

  – however, 17 companies recorded in Annex L of standard

  – 7 registered in ISO patent database

  – 12 registered in ITU-T database (4 claim not RF!)

  – 20 in JPEG collection (scanned ISO plus document register)

  – in many cases statements ambiguous, legalistic, etc

  – original Japanese search found 4000+ possible patents

❖ Status: Full IS, Dec 2000. Updated version Sep. 2004

JPEG 2000 Part 1
Core coding system

❖ Currently working on amendment, extending profiles for digital cinema (complete in 2008)

❖ Basically work is complete - covers baseline implementation of compression scheme, similar to original JPEG, but with simple file format defined.

❖ Wavelet, lossy or lossless, simple regions of interest, colour space specified, large images, many components etc etc

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JPEG 2000 Part 2
Extensions

- ❖ Added more flexible alternate methods for compression, improvements to ROI coding, JPX file format (extended colour spaces, metadata handling, multiple image files in one container)

- ❖ Patent situation relatively unknown and somewhat concerning as toolkit standard

- ❖ Status: Full IS, Nov. 2001, Updated May 2004

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JPEG 2000 Part 3
Motion JPEG 2000

❖ Now a key part of the standard - adopted by Digital Cinema Initiative (www.dcimovies.com) for coding video for releases in cinemas.

❖ Disney, Fox, Paramount, Sony, Universal, Warner Bros…

❖ Interest in higher quality, stereoscopic, archival - however core will be defined by DCI - 2k x 1k or 4k x 2k at 24 or 48 Hz, 12bit XYZ colour space, uncompressed audio

❖ Lower compression than MPEG standards, but allows frame perfect edits/capture etc, plus major licensing advantages assumed

❖ Current work: Interoperability tests, HDTV conversion, archiving

❖ Status: Full IS Nov. 2001

JPEG 2000 Part 4
Conformance

- ❖ Everyone hates working on conformance testing….
- ❖ Too many possible options
- ❖ However, wide range of test streams generated, and have helped development
- ❖ Doesn't test performance, robustness etc…
- ❖ Status: Full IS, May 2002

JPEG 2000 Part 5 Reference Software

❖ What can I say…

❖ JJ 2000 - Java implementation and Jasper (c)

❖ Part 1 only

❖ Jasper has continued to be developed, and is relatively mature - used in a wide range of Open Source projects

❖ Also have Open JPEG and Kakadu, as relatively mature options from university bases

❖ Many other commercial options - Pegasus, Luratech, Aware etc with particular specialisations

❖ No current work…

❖ Status: Full IS, Nov. 2001

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JPEG 2000 Part 6
Compound image file format

❖ Used to store multi page documents with many objects per page

❖ Combines best compression technologies together - JBIG2, JPEG 2000, JPEG-LS etc

❖ Based on ITU-T mixed raster content (MRC) standard (IS 16485)

❖ Claimed compression ratios 25 Mbyte A4 page scanned at 300 dpi can reduce to 100k bytes

❖ Luratech, Xerox and others have toolkits

❖ Activity at present includes allowing hidden text for OCR purposes

❖ Status: Full IS, Apr. 2003

JPEG 2000 Part 7
No there really isn't a part 7…

❖ Nope, not even pining…

❖ Status: dead…

JPEG 2000 Part 8
JPSEC - Secure JPEG 2000

❖ Allows protected images to retain features such as scalability, with possibility to encrypt layers of image with different characteristics

❖ Works with other parts, such as JPIP

❖ Intention is to use for distribution of protected images through variety of methods

❖ Status: Full IS, July 2006

❖ Working on
  – securing the File Format (complete Mar. 2008)
  – conformance testing (complete Jul. 2008)

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JPEG 2000 Part 9
JPIP - Interactivity tools, APIs & protocols

❖ Lot of activity - developers include Luratech, Kakadu, ITT, Ricoh, Aware, TUB, + significant input from Elysium

❖ Most recently successful interoperability testing, and discussion on best ways to optimise images for delivery

❖ Allows metadata to be linked to parts of image

❖ Demo - if time permits…

❖ Status: Full IS, Oct. 2004

❖ Working on
– server/client profiles (Mar. 2008)
– some extensions which could not be initially included (Jul. 2007)
– extensions for 3D image browsing (Jul. 2008)

JPEG 2000 Part 10
JP3D - Extensions for 3D data

❖ Ready for publication

❖ Volumetric test set and verification software developed and available within JPEG

❖ Increasing interest

❖ Status: Full IS, July 2007 (tentative)

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JPEG 2000 Part 11
JPWL - Wireless

- ❖ Developed using Open JPEG software - www.openjpeg.org
- ❖ JPWL reference software and JPWL compliance test streams are available
- ❖ Some known patents - hopefully RF
- ❖ Offers significantly better performance over high noise networks
- ❖ Other applications - wireless connection to projector for example
- ❖ Current activities looking at integration of MJ2 streams over wireless
- ❖ Status: Full IS, April 2007

JPEG 2000 Part 12
ISO base media file format

- ❖ It's a file format…
- ❖ And you need it for motion JPEG 2000
- ❖ And it looks awfully like Quicktime
- ❖ And MPEG use the same one in MP4….
- ❖ Status: Full IS, Jul. 2003

JPEG 2000 Part 13
An entry level JPEG 2000 encoder

- ❖ Well - did we get the patents right…?
- ❖ Because if we didn't
- ❖ What is normative, and when should you declare your patents?
- ❖ So if this is ever going to be used in a digital camera….
- ❖ Let's ask the question
- ❖ Driven by Japanese industry
- ❖ Uphill struggle to get patent statements
- ❖ Status: Full IS, Jun. 2007

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JPEG 2000 Part 14
XML structural representation & reference

- ❖ Proposed in March 2007, Ricoh and others
- ❖ Standardises an XML form for the representation of a JPEG 2000 file
- ❖ Allows range of tools to work with JPEG 2000 files, accessing parts of their structure
- ❖ Allows potential for compressed XML
- ❖ Better possibilities for import and export of existing and future file formats
- ❖ Status - outline proposal only. FCD by March 2008, IS by Mar. 2009

JP Search

- ❖ Aims to develop a standard framework for searching large collections of images
- ❖ Initial part of the standard (IS 24800-1) is basically a technical report
- ❖ Intent is to allow novel methods of searching to be linked into conventional ones
- ❖ Identifies the problems very well
- ❖ However…
- ❖ Also related to work in MPEG on multimedia application farmeworks
- ❖ Intent is to standardise interface to query engines to some extent
- ❖ Early days, but interest growing

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Advanced Image Coding (AIC)

❖ Watching brief on technologies and methods

❖ Looking for novel approaches, but no-one really expects a breakthrough in compression terms

❖ Currently still deciding on evaluation methodologies

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HD Photo

- ❖ Massive interest - Microsoft presented in San Jose
- ❖ Claimed that it will be license and royalty fee free
- ❖ Similar to JPEG 2000 in some respects - bit depth, high gamut, alpha channels, lossy/lossless
- ❖ Claims of better error spreading of artefacts
- ❖ Asked that JPEG consider standardising it under AIC
- ❖ Already inside Vista as Windows Imaging Component
- ❖ Target is high end cameras primarily
- ❖ Heavy commitment from Microsoft to support
- ❖ Elysium currently chairing ad hoc group evaluating technology
- ❖ Relationship to JPEG should be decided at next meeting - JPEG Lausanne, July 2007