JPEG2000

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JPEG2000 Features

Scalable code-stream
Progressive transmission
  Quality
  Resolution
  Spatial location
  Component
Lossless (available naturally by progression)
Binary (as well as continuous tone) imagery
Random code-stream access
Region of interest
Superior compression performance
JPEG2000 Compression
Progression by Resolution
Progression by Quality

0.03125 bpp, 768:1, 1024 bytes

0.0625 bpp, 384:1, 2048 bytes
Progression by Quality (cont.)

0.125 bpp, 192:1, 4096 bytes

0.25 bpp, 96:1, 8192 bytes
Progression by Quality (cont.)

Lossless, 1.76:1
Progression by Spatial Location
Progression by Component
Progression Order Change

Progression orders can be mixed and matched within a single code-stream.
Region of Interest
Comparison with JPEG @ 0.25 bpp
The JPEG2000 Algorithm
Color Transforms: Enable Color Scalability

Allowed only for three components with same subsampling and bit depth

Applied independently to each color pixel

Resulting Y component is monochrome (e.g., B&W TV)

Cb, Cr are chrominance components (color info)

Most energy is in Y — Cb and Cr are highly compressible

Improves compression efficiency

More transforms allowed for Part-2 (e.g., KLT, wavelet)
Two color transforms are supported

Irreversible color transform (ICT)
  RGB to YCbCr (real numbers, in general)
  Useful for high performance lossy compression
  Does not support lossless compression

Reversible color transform (RCT)
  Integer approximation of ICT
  Useful for lossy and lossless compression
Example RGB Images

Note that the color components are highly correlated
Example YCbCr Images

Dynamic range of Cb and Cr is significantly reduced as compared to B and R
Cb and Cr are highly compressible
Wavelet Transform: Enables Resolution Scalability

The filtering perspective

1-D Forward Wavelet Transform

1-D Inverse Wavelet Transform
2D Transform: An Example
Wavelet Transform: Example (again)

Same as previous chart, but LH, HL, HH stretched for display
Wavelet Transform Example: Two Levels (Three Resolutions)
Wavelet Transforms in JPEG2000

Two versions

Irreversible (floating point 9/7 — high performance lossy)

Reversible (Integer 5/3 — lossy and lossless)

Correspondence to the ICT and RCT, respectively

More flexibility in Part-2

9/7 can be described by either “convolution” or “lifting”

5/3 can only be described via lifting

Boundaries are handled via symmetric extension
Embedded Deadzone Quantization: Enables Quality Scalability

Scalar quantization with deadzone

Allows real numbers to be approximated by integers

\[
\begin{pmatrix}
-4\Delta & -3\Delta & -2\Delta & -\Delta & 0 & \Delta & 2\Delta & 3\Delta & 4\Delta
\end{pmatrix}
\]

\[q = Q(y) = \text{sign}(y) \left\lfloor \frac{|y|}{\Delta} \right\rfloor\]

\[\hat{y} = Q^{-1}(q) = \text{sign}(q)(|q| + r)\Delta\]

Dropping LSB of \( q \) is equivalent to doubling step size

Separate step size allowed for each subband

No quantization necessary for reversible transforms

Effectively then, \( \Delta = 1 \)
Embedded Quantization (cont)

Coupled with bit-plane coding for quality scalability
Overly simplified – More details to follow

• Resolution Progressive
  - Send quantized data in order of increasing scale

• SNR Progressive
  - Send bits in order that minimizes MSE
Codeblocks within Subbands: Enable Spatial Random Access
This book is intended to serve as a textbook on image compression fundamentals, as well as the definitive reference on JPEG2000
Includes full source implementation of JPEG2000 Part 1, with some Part 2 extensions
Interactive Browsing - Demo

Very large image

14680H x 14565W pixels
uncompressed - 204 MB
  attempted display of TIF often crashes my computer!
  JP2 file compressed to 1.5 bpp - 38 MB

Demo 1 - High speed communication link
  Seamless delivery

Demo 2 - Low speed link
  Typical phone modem speed - 32 kbits/sec
  Use of progressive transmission readily apparent
  Highly responsive browsing is achieved even though download of entire compressed file would require 2.2 hours