# The New JPEG 2000 Part 2 Multi-Component Transfer Syntaxes

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# Background

- What is JPEG 2000?

    - Multi-part image coding standard published by ISO SC29/WG1

    - Part 1: core coding system, finalized in Dec. 2000

    - Part 2: Extensions to technology in Part 1, including multi-component transformations

    - Parts 3-12: motion, compliance, wireless, security, etc.

- DICOM Supplement 61: Part 1 JPEG 2000 Transfer Syntaxes

    - Final Text in January 2002

    - Lossless and Lossy compression

    - Progressive and embedded spatial and quality resolution

    - Progression from lossy to lossless

    - Single frames or 3 channel color compression only

# JPEG 2000 Part 2, Extensions

## Multi-component transformations:

- Extensions to RGB-YUV color transformations

- Designed for hyper-spectral, multi-component, volumetric or multi-frame imagery

- Transform is applied to each pixel in the image, in the 3rd direction

- After applying multi-component transformation, each frame is compressed using standard JPEG 2000 Part 1 compression.

- More than one transformations can be applied in sequence

- Transformations can be applied independently to component collections (groups of frames)

# Multi-component transforms

3 Different types:

- Linear Block Transforms
  - Matrix multiplication ( $Y = A^t X$)
  - Examples: Part 1 color transforms, other color rotations, KLT, etc.
- Dependency transforms
  - Predictive coding: $y[n] = x[n] - F(x[0], x[1],…, x[n-1] )$
  - Example: DPCM
- Wavelet transforms
  - 9-7 (floating point) and 5-3 (integer) filters
  - Also used in JPEG 2000 Part 1 compression

# DICOM Supplement 105

- JPEG 2000 Part 2 multi-component transformations
  - Two specific wavelet transforms
  - dependency transforms
  - linear block transforms
- More than one transformation to be applied in succession
- Component collections
  - Groups of frames that are transformed independently
  - Reduces computational complexity
  - Improves access to specific frames on the decoder.
- Sub-resolution decoding in the third dimension, resulting in subset of frames, each image is essentially an average of N (2,4,8) frames

# DICOM Supplement 105

- 2 new transfer syntaxes
  - Lossless only
  - Lossless or lossy

- Status of Supplement:
  - Work Item initiated in WG-06 in March 2004
  - Final Text approved in June 2005

- Improvements over Supplement 61 (Part 1, JPEG 2000)
  - 10-20% higher lossless performance
  - Lossy: 2-3 times higher compression ratio at specific image quality
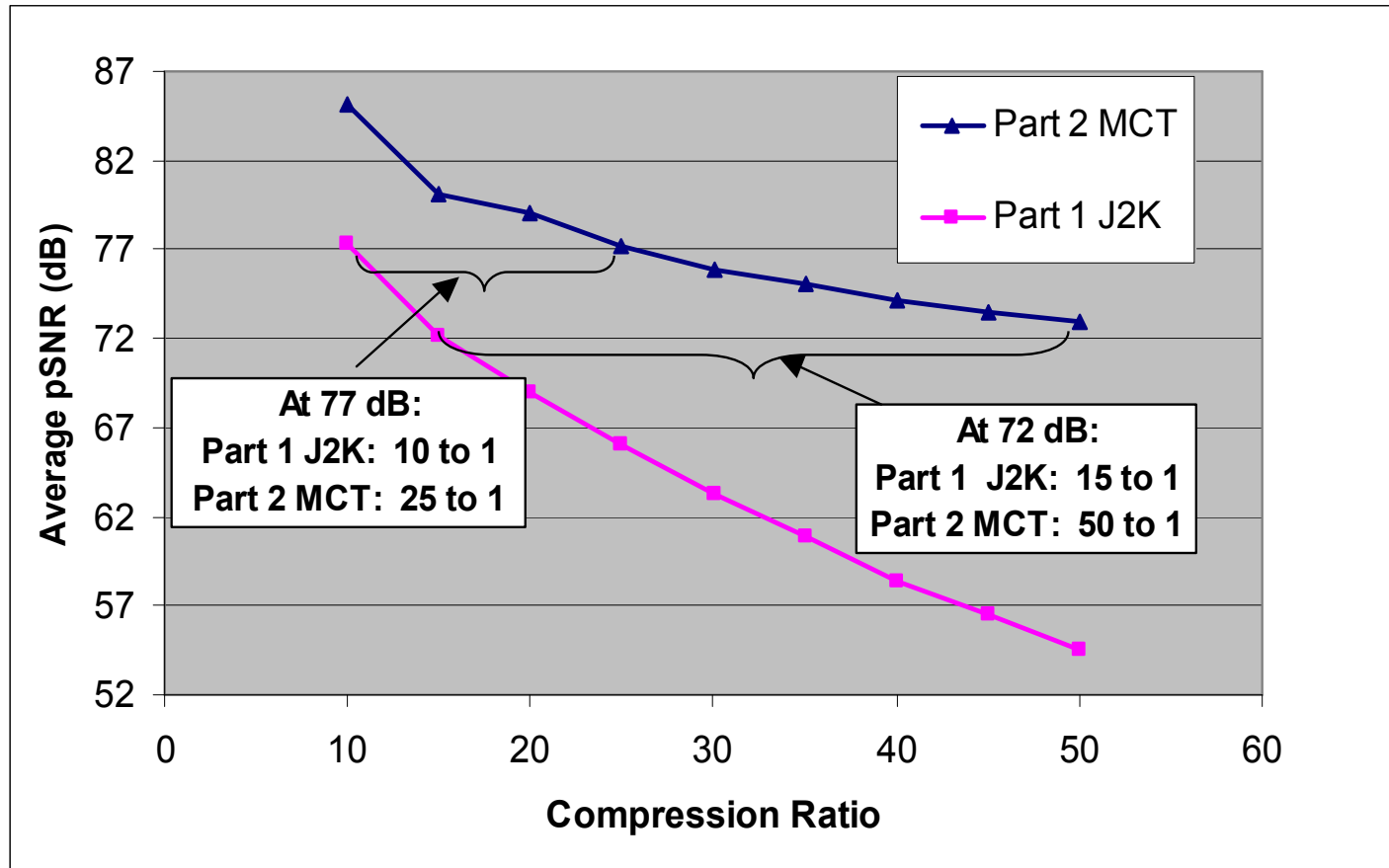
# MCT Performance

## Comparison of different multi-component transforms

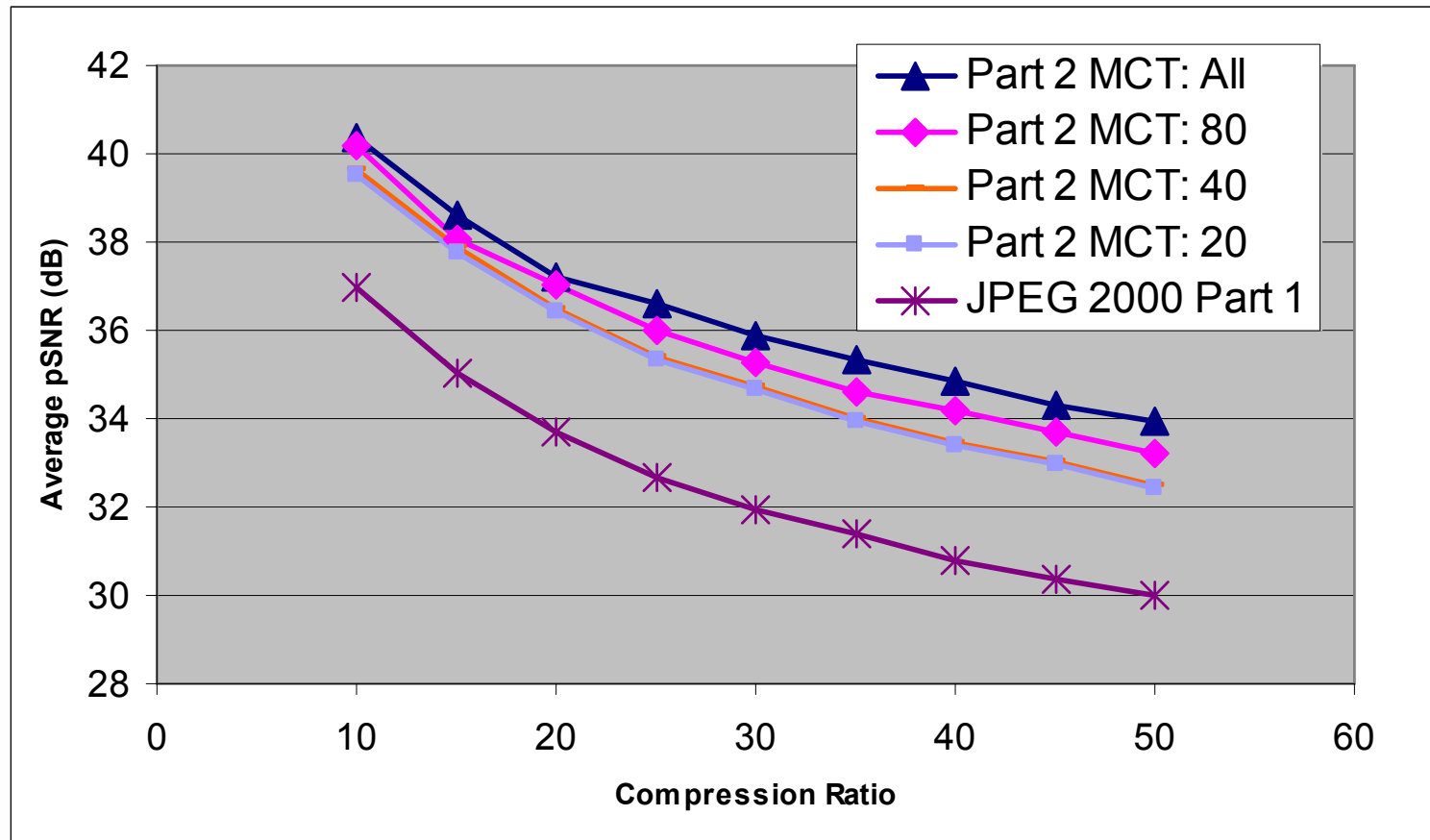| Technique | Compressed Size (Mbytes) | Compression ratio Lossless |
|---|---|---|
| JPEG 2000 Part 1, no multi-component transform | 40.1 | 3.64 |
| Mean based predictive | 37.8 | 3.80 |
| 1st order predictive | 32.1 | 4.78 |
| 5-3 Wavelet 5 levels | 29.9 | 4.88 |

Original Sequence: 145 MBytes

# Example Performance

# Component collections

# Example Performance

## Sequence Information

| Sequence | Image size | # of images (N) | Bitdepth | Uncompressed sequence size |
|---|---|---|---|---|
| Seq. #1 | 256 x 256 | 127 | 8 | 7.9 Mbytes |
| Seq. #2 | 512 x 512 | 449 | 16 | 224 Mbytes |
| Seq. #3 | 512 x 512 | 620 | 16 | 310 Mbytes |

## Performance comparison at different collections sizes

| Sequence | Part 1 JPEG 2000 compressed size (Mbytes) | Part 2 JPEG 2000 compressed size, at different component collection sizes (Mbytes) | | | | Improvement (over Part 1, for N) |
|---|---|---|---|---|---|---|
| | | 20 | 40 | 80 | N | % |
| Seq. #1 | 3.81 | 3.27 | 3.25 | 3.24 | 3.23 | 15.2 |
| Seq. #2 | 75.8 | 62.7 | 62.3 | 62.1 | 61.8 | 18.5 |
| Seq. #3 | 120 | 105 | 104 | 101 | 100 | 16.7 |

# Demonstration

- Volumetric Data compression

- Comparison of

  - Part 1 JPEG 2000 compression

  - Part 2  MCT JPEG 2000 compression

  - Lossless compression ratio

  - Lossy compression ratio -- image quality in pSNR

  - Effect of different component collection values


- Combination with Supplement 106 (JPIP)

  - efficient browsing of volumetric data