Impact of New DICOM Objects on Handling Large Data Sets

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Disclosures

• David Clunie, MB., BS., FRACR
  – CTO, RadPharm, Inc. (formerly Princeton Radiology Pharmaceutical Research)
  – PixelMed Publishing - contractor for the NEMA Enhanced CT and MR test tools and images
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Large Datasets

• Pose not just challenges due to their sheer bulk (time and cost to transfer and store)
• An interoperability challenge in terms of how the data is organized and how it should be navigated, rendered and analyzed
• A paradigm challenge in terms of new application and visualization concepts
DICOM Challenges

• Expansion of scope
  – From images to workflow, reporting, therapy …

• Evolution of modality technology
  – Speed and resolution of CT
  – Pulse sequences, gradients and field strength in MR

• Evolution of clinical applications
  – Enabled by technology
  – Enabled by contrast agents and radionuclides
DICOM Challenges

• More information
• More slices
• More complex applications on workstation

• Greater expectations of inter-functionality between different vendors modalities and workstations
1993 DICOM Image Objects

- Computed Radiography
- Computed Tomography
- Magnetic Resonance Imaging
- Nuclear Medicine
- Ultrasound
- Secondary Capture
2005 DICOM Image Objects

- Computed Radiography
- Computed Tomography
- Magnetic Resonance Imaging
- Nuclear Medicine
- Ultrasound
- Secondary Capture
- X-Ray Angiography
- X-Ray Fluoroscopy
- Positron Emission Tomography
- Radiotherapy (RT) Image
- Hardcopy Image
- Digital X-Ray
- Digital Mammography
- Intra-oral Radiography
- Visible Light Endoscopy & Video
- VL Photography & Video
- Visible Light Microscopy
- Multi-frame Secondary Capture
- Enhanced MR
- MR Spectroscopy
- Raw Data
- Enhanced CT
- Enhanced XA/XRF
- Ophthalmic Photography
2005 DICOM Non-Images

- Radiotherapy (RT) Structure Set, Plan, Dose, Treatment Record
- Waveforms (ECG, Hemodynamic, Audio)
- Grayscale, Color and Blending Presentation States
- Structured Reports
- Key Object Selection
- Mammography and Chest Computer Assisted Detection (CAD)
- Procedure Log
- Spatial Registration and Fiducials
- Stereometric Relationship
What is *Interoperability*?

- Analogy of web server/browser:
  - Inter-connectivity - both talk TCP/IP
  - Inter-operability - both talk HTTP and HTML
  - Inter-functionality - not guaranteed:
    - “versions” of HTML poorly controlled
    - layout not constrained by HTML
    - availability of proprietary extensions (plug-ins, applets)
    - e.g., “this page only for IE version 5.0”

- Good, but not good enough for healthcare
DICOM and *Interoperability*

- For example, conformance to DICOM
  - will guarantee network connection
  - will guarantee storage of MR image:
    - from Modality to Workstation
  - will NOT guarantee (but will facilitate):
    - workstation will display image “correctly”
    - workstation can perform the analysis the user wants
  - facilitated by mandatory attributes for:
    - identification, annotation, positioning, etc.
    - newer DICOM objects increase what is mandatory
Greater Interfunctionality

• Some clinical scenarios for new DICOM images
  – Cardiac motion - vendor independent applications that handle spatial and temporal (cardiac cycle) CT and MR images
  – Diffusion MR - vendor independent applications that handle diffusion B value and direction
  – Multi-stack spine - vendor independent applications that recognize stacks of parallel slices through inter-vertebral disk spaces
  – Contrast and perfusion - vendor independent applications that recognize timing and phase of enhancement in CT and MR images for display and or quantitative analysis
  – Spectroscopy - vendor independent applications that process and display single-voxel, multi-voxel or multi-slice MR spectra and reference and metabolite map images
Enhanced DICOM Images

- Enhanced MR Image - Supplement 49
- Enhanced CT Image - Supplement 58
- Enhanced XA/XRF - Supplement 83
- Enhanced PET - work in progress
Multi-frame Organization of New CT & MR Images

• Original objects
  – Series organization + single frame + a few attributes + terms

• Enhanced objects
  – Multiple frames in a single object
  – Many more standard mandatory attributes
  – Many more standard terms

• Enables
  – Greater interfunctionality of applications
  – More effective hanging protocols
  – Reduced dependence on private attributes
## Technique Attributes & Terms

<table>
<thead>
<tr>
<th>SOP Class</th>
<th>CT Original</th>
<th>CT Enhanced</th>
<th>MR Original</th>
<th>MR Enhanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attributes (Mandatory)</td>
<td>18 (0)</td>
<td>41 (39)</td>
<td>44 (2)</td>
<td>103 (94)</td>
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<tr>
<td>Terms (Enumerated)</td>
<td>4 (2)</td>
<td>86 (18)</td>
<td>38 (9)</td>
<td>228 (47)</td>
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</table>
CT Image Type Value 3

- **Original SOP Classes**
  - AXIAL or LOCALIZER

- **Enhanced SOP Classes**
  - Common to CT and MR
    - ANGIO, FLUOROSCOPY, LOCALIZER, MOTION, PERFUSION, PRE_CONTRAST, POST_CONTRAST, REST, STRESS, VOLUME
  - CT-specific
    - ATTENUATION, CARDIAC, CARDIAC_GATED, REFERENCE
MR Acquisition Contrast

• Original SOP Classes
  – Guess from echo and repetition time, etc.

• Enhanced SOP Classes
  – New mandatory frame level attribute
  – Acquisition Contrast

  ➢ DIFFUSION, FLOW_ENCODED, FLUID_ATTENUATED,
    PERFUSION, PROTON_DENSITY, STIR, TAGGING, T1,
    T2, T2_STAR, TOF, UNKNOWN
Geometry unchanged

- Same as original SOP Classes
- Image Position and Orientation (Patient)
- Still need to compute AXIAL, SAGITTAL or CORONAL from orientation vector
- Still need to compute edge labels (A/P etc) from orientation vector
- May still need to compare orientation vectors to determine if slices are parallel - stacks will be discussed later
Enhanced Contrast/Bolus

• Original SOP Classes
  – Plain text description
  – Difficult to determine presence/absence
    ➢ E.g., description value of “None”
  – Single agent (did not distinguish oral/iv)
  – Codes optional and never used

• Enhanced SOP Classes
  – Mandatory codes only
  – Multiple items with separate coded routes & timing
  – Presence or absence per-frame can be described
Coded anatomic regions

• Original SOP Classes
  – Incomplete list of optional defined terms
  – Optional laterality

• Enhanced SOP Classes
  – Mandatory coded anatomic region
  – Comprehensive & appropriate list of codes
  – Mandatory laterality
  – Per-frame or for entire object
Hanging protocol rule impact

- T1 SAG PRE GD
- T1 AXIAL PRE GD
- T2 AXIAL
- T1 AXIAL POST GD
Hanging protocol rule impact

T1 SAG PRE GD
T1 AXIAL PRE GD
T2 AXIAL
T1 AXIAL POST GD

Acquisition Contrast = T1
Hanging protocol rule impact

T1 SAG PRE GD
T1 AXIAL PRE GD
T2 AXIAL
T1 AXIAL POST GD

Acquisition Contrast = T1
Hanging protocol rule impact

Acquisition Contrast = T1
Image Orientation ≈ 0\1\0\0\0\1
Hanging protocol rule impact

T1 SAG PRE GD
T1 AXIAL PRE GD
T2 AXIAL
T1 AXIAL POST GD

Acquisition Contrast = T1
Image Orientation ≈ 0\1\0\0\0\0\1
T1 SAG PRE GD
T1 AXIAL PRE GD
T2 AXIAL
T1 AXIAL POST GD

Acquisition Contrast = T1
Image Orientation ≈ 0\1\0\0\0\-1
Contrast Agent #1
  Administered = NO
  Route = (G-D101,SNM3, “IV”)
  Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule impact

Acquisition Contrast = T1
Image Orientation ≈ 0\1\0\0\0\-1
Contrast Agent #1
  Administered = NO
  Route = (G-D101,SNM3, “IV”)
  Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule impact

Acquisition Contrast = T1  
Image Orientation ≈ 1\0\0\0\1\0  
Contrast Agent #1  
Administered = NO  
Route = (G-D101,SNM3, “IV”)  
Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule impact

Acquisition Contrast = T1
Image Orientation ≈ 1\0\0\0\1\0
Contrast Agent #1
Administered = NO
Route = (G-D101, SNM3, “IV”)
Ingredient = (C-17800, SRT, “Gd”)
Hanging protocol rule impact

Acquisition Contrast = T1
Image Orientation ≈ 1\0\0\0\1\0
Contrast Agent #1
  Administered = NO
  Route = (G-D101,SNM3, “IV”)
  Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule impact

T1 SAG PRE GD  T1 AXIAL PRE GD  T2 AXIAL  T1 AXIAL POST GD

Acquisition Contrast = T2
Image Orientation ≈ 1\0\0\0\1\0
Hanging protocol rule impact

- T1 SAG PRE GD
- T1 AXIAL PRE GD
- T2 AXIAL
- T1 AXIAL POST GD

Acquisition Contrast = T2
Image Orientation ≈ 1\0\0\0\1\0
Hanging protocol rule impact

T1 SAG PRE GD  T1 AXIAL PRE GD  T1 AXIAL POST GD

Acquisition Contrast = T2
Image Orientation ≈ 1\0\0\0\1\0
Hanging protocol rule impact

Acquisition Contrast = T1
Image Orientation ≈ 1\0\0\0\1\0
Contrast Agent #1
Administered = YES
Route = (G-D101,SNM3, “IV”)
Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule
impact

- T1 SAG PRE GD
- T1 AXIAL PRE GD
- T2 AXIAL

Acquisition Contrast = T1
Image Orientation ≈ 1\0\0\0\1\0
Contrast Agent #1
    Administered = YES
    Route = (G-D101,SNM3, “IV”)  
    Ingredient = (C-17800,SRT, “Gd”)
Hanging protocol rule impact
Hanging protocol rule impact

Same rules, independent of whether:
• one single multi-frame image
• one multi-frame image per acquisition
• one slice per single frame image
• one series or multiple
Hanging protocol support

- A productivity advantage of the CT and MR objects
- Should not have to tailor hanging protocol rules to specific vendors or devices or versions
- Reliable and standard information
  - Mandatory and standard places (attributes)
  - Mandatory and standard values
- As technology evolves, yet more standard values will be added to the standard
- Eliminate dependence on site configured Series Number or Series Description, whether from acquisition protocol or entered by operator
Dynamic Contrast

• Conventional hanging protocols are rarely sophisticated enough to recognize multiple phases of contrast enhancement, e.g., during CT of liver

• Old DICOM objects have no standard information about contrast phase

• New objects name phases of contrast administration for each frame
  – PRE_CONTRAST, POST_CONTRAST, IMMEDIATE, DYNAMIC, STEADY_STATE, DELAYED, ARTERIAL, CAPILLARY, VENOUS, PORTAL_VENOUS
Hanging protocol rule
impact - dynamic contrast

PRE
ARTERIAL
DELAY
Hanging protocol rule impact - dynamic contrast
Hanging protocol rule
impact - dynamic contrast
Hanging protocol rule impact - dynamic contrast
DICOM Hanging Protocols

- Foregoing describes how to use attributes in Enhanced CT and MR objects to improve any hanging protocol engine, including proprietary software.
- DICOM also has recently defined Hanging Protocol SOP Classes.
- To store hanging protocol rules centrally and exchange them between different systems.
- Not a pre-requisite for making use of the enhanced image objects to improve hanging.
Beyond simple image display

• Visualization
• Temporal change
  – Short term
  – Long term
• Quantitation and Analysis
Visualization

• MPR
• 3D surface and volume rendering
• MIP for angiography
Temporal change

• Short term
  – Perfusion
  – Cardiac cycle

• Long term
  – Change between studies
Quantitation and analysis

• Processing of multiple frames
• Measurement of morphology
  – Linear distance
  – Volumetrics
• Measurement of physiology and function
  – Perfusion and diffusion
  – fMRI
• Registration
  – between acquisitions, studies & modalities
Supporting advanced applications

• Original SOP Classes
  – Minimal standard acquisition information
  – Imprecisely defined timing information
  – No organizational structures except Series
  – Quantitation mixed with grayscale pipeline

• Enhanced SOP Classes
  – Detailed descriptions of advanced acquisition protocols
  – Accurate and well-defined timing information
  – Pre-defined organizational structures
  – Quantitative values and color support
Enhanced MR attribute types

- Separate gradient and RF echo train lengths
- Out-of-plane phase encoding steps
- Flow compensation
- Spectrally selective excitation & suppression
- Blood signal nulling
- Tagging
- Diffusion values and direction
- Spatial saturation slabs
- Velocity encoding
- Chemical shift imaging (metabolite maps)
Enhanced CT attribute types

- Acquisition type
- Constant volume and fluoroscopy
- Single and total collimation width (for multiple detectors)
- Table speed, feed and spiral pitch factor
- Reconstruction geometry and convolution kernel
- Exposure information, dose savings and $\text{CTDI}_{\text{Vol}}$
Timing information

• Original SOP Classes
  – Inconsistent use of Content (Image) and Acquisition Time
  – Contrast timing information never used

• Enhanced SOP Classes
  – Unambiguous definition of acquisition timing
  – Explicit relationships with contrast & cardiac timing
Timing information

- Patient prepared
- Scanner adjusted to patient
- Frame Reference Datetime
- Acquisition Datetime
- Frame Acquisition Datetime
- Frame Acquisition
- Acquisition Duration
- Frame Acquisition Duration
- Time

- Patient preparation
- Scanner adjustment
Timing information

Cardiac R-R Interval Specified (0018,9070): R-R interval in ms at prescription time.

Trigger Delay Time (0020,9153): prescribed delay in ms after latest R-peak.
Contrast timing

• Numeric - Administration Profile
  – Allows for multiple contrast agents and phases
  – Volume, start/stop times, rates and duration

• Categorical
  – Can be specified on a per-frame basis
  – Administered - YES/NO
  – Detected - YES/NO
  – Phase - PRE_CONTRAST, POST_CONTRAST, IMMEDIATE, DYNAMIC, STEADY_STATE, DELAYED, ARTERIAL, CAPILLARY, VENOUS, PORTAL_VENOUS
Contrast timing - phase for hanging protocols
Organizational Features

- Multi-frame pixel data
- Shared and per-frame functional groups
  - Each functional group contains attributes that likely vary as a group, e.g. Pixel Measures, Plane Orientation, Velocity Encoding, etc.
  - Compact & makes explicit what doesn’t change
- Dimensions
  - *a priori* hints as to how the frames are organized
  - Specify intended order of traversal, such as space, then time (e.g., for cardiac cine loops)
- Stacks
  - Groups of spatially-related slices, repeatable
- Temporal positions
Organization of Data

- Goal is to reduce the work that the receiving application has to do to “figure out”
  - How the data is organized
  - Why it is organized that way
- Without preventing use of the data in unanticipated ways
  - E.g. 3D on a dataset not intended as a volume
- Two levels
  - The detailed shared & per-frame attributes
  - The overall dimensions, stacks and temporal positions
Multi-frame Functional Groups

- Shared attributes
- Per-frame attributes
- Pixel data
Stacks

Frame Number 27 - 31
Stack ID3

Frame Number 19 - 23
Stack ID2

Frame Number 1 - 5
Stack ID1
Dimensions

Start with a dimension of space.

A set of contiguous slices through the heart.
Add dimension of time (delay time from R-wave).

Sets of contiguous slices throughout cardiac cycle.
Temporal Position Index 2

Trigger Delay Time
48 ms

Temporal Position Index 2

In-Stack Position

Stack ID = 1

Dimension Index Values
1 \ 5 \ 2

Dimension Index Pointers:
1. Stack ID
2. In-Stack Position
3. Temporal Position Index

Stack ID = 1

Time (2)

Space (1)
Temporal Position Index
2

Trigger Delay Time
48 ms

Temporal Position Index
2

In-Stack Position
Stack ID = 1

Dimension Index Values

1 \ 5 \ 2

Dimension Index Pointers:
1. Stack ID
2. In-Stack Position
3. Temporal Position Index

In-Stack Position

Stack ID = 1

Time (2)

Space (1)
Temporal Position Index 2

Trigger Delay Time
48 ms

Temporal Position Index 1

Stack ID = 1

Dimension Index Pointers:
1. Trigger Delay Time
2. Stack ID
3. In-Stack Position

Dimension Index Values:
2 \ 1 \ 5

In-Stack Position

Time (1)

Space (2)
Dimension features

• Description of dimensions separate from their indices
  – Dimensions are described once
  – Indices within dimensions are encoded per-frame

• Receiving application only needs to follow the index values
  – Does NOT need to select or sort by attribute value
  – Dimensions can be entire functional groups
  – Dimensions can be private attributes or functional groups
Dimension applications

- Selection of sort order for simple viewing
- Partitioning of frames for hanging
- Selection of frames that constitute a
  - volume in space
  - temporal sequence
  - contrast administration phase
  - physiological parameter, e.g. diffusion b value
Quantitation of pixel values - Real World Values

- Stored Values
  - Modality LUT
  - VOI LUT
  - P LUT
  - Display

Real World Value LUT
Real World Value Intercept and Slope attributes
Measurement Units Code Sequence
(0040,9212) or (0040,08EA)
In this case values included:

- Linear, identity mapping
- Output of mapping; with code meaning of units
- Coordinates of current cursor position
- Cursor over pixel
- In this case values included; linear, identity mapping
- Stored pixel value

(58,66) = 995.0 cm²/s \times 10^{-6} [995]
Real World Values

- Separate from grayscale pipeline
- May be non-linear
- May be multiple mappings into different units
Color display of functional data

- Range of stored values to be mapped to grayscale
- Range of stored values to be mapped to color
- Modality LUT
- VOI LUT
- P-LUT

First stored pixel value mapped (2nd value of LUT descriptor)
Palette color
Number of entries
RGB values by display device
Mapped to gray level

Color Display
Color by functional paradigm

Anatomic Reference → VOI → LUT → Grayscale Window/Level
Color by functional paradigm

Pixel Values

- Anatomic Reference
- VOI LUT
- Grayscale Window/Level
- Left Motor Paradigm
- Right Motor Paradigm
- Language Paradigm
- Color Map
Color by functional paradigm

Pixel Values
- Anatomic Reference
- VOI LUT
- Grayscale Window/Level
- Left Motor Paradigm
- Right Motor Paradigm
- Language Paradigm

Z-score Map
- Z=5.1
- No Z
- Z=4.9
- Z=5.1

Z Score Real World Value Map
Color information applications

Perfusion

Diffusion

Functional
Color is *not* used for Multi-modality fusion

- Intention is to limit color use *in image* to where
  - Information is known added at acquisition
  - Involves pixel value replacement
  - Needs windowing of underlying grayscale
- Does not support transparency
- Separate new DICOM objects for
  - Spatial registration and fiducials
  - Blending presentation state for fusion
  - New enhanced multi-frame PET in development
Multi-modality fusion - Blending Presentation State
Blending for multi-modality fusion

select
underlying

select
superimposed
Blending for multi-modality fusion

- select underlying
- [register]
- select superimposed
Blending for multi-modality fusion

1. Select underlying
2. [Register]
3. Select superimposed
4. Resample
Blending for multi-modality fusion

- Select underlying
- [Register]
- Select superimposed
- Resample within slices
Blending for multi-modality fusion

- select underlying
- [register]
- select superimposed
- resample
- within slices
- [between slices]
Blending for multi-modality fusion

- select underlying
- [register]
- rescale and window

- select superimposed
- resample
- within slices
- [between slices]
Blending for multi-modality fusion

- select underlying
- [register]
- rescale and window

- select superimposed
- resample
- within slices
- [between slices]
- pseudo-color
Blending for multi-modality fusion

1. Select underlying
2. [Register]
3. Rescale and window
4. Blend

Select superimposed resample within slices
5. [Between slices]
6. Pseudo-color
Spectroscopy

Choline
Creatine
NAA
Lactate
2000/144
Metabolite Maps
MR Spectroscopy

Storage of Spectroscopy Data

Metabolite Maps
MR Spectroscopy

- Two types of data
  - Spatially localized spectra (signal intensity versus frequency or time)
  - Images of one particular part of the spectrum (chemical shift image or metabolite map)
- Metabolite maps are stored as images
- Spectra cannot be not stored as pixel data
- In the past - stored as screen saves of curves
- Now - MR Spectroscopy SOP Class
  - Arrays of floating point and/or complex values
  - 1D or 2D data for single or multiple voxels and frames
  - Allows for interaction, analysis and quantitation
Raw Data

• MR and CT have “raw data” prior to reconstruction into spatial domain images (k-space data, raw views)
• Need for different reconstructions
  – Slice thickness and reconstruction interval
  – Different convolution kernel (bone, lung)
  – Different field of view
  – For CAD versus human viewing
• Raw data is bulky and proprietary
• Local long term archival on modality possible but unusual and inconvenient, therefore time window for retrospective reconstruction is limited
Raw Data SOP Class

- Goal is storage of encapsulated raw data in the PACS or other central archive
- Without standardizing raw data format
- Defines usual patient, study, series, instance attributes
- No standard payload - raw data assumed to be in private attributes
- Allows for storage and retrieval without understanding
- No expectation that different vendors will be able to use the data
- SOP Instance UID of raw data can be referenced from images and spectra
Performance Opportunities

• New multi-frame object does not change
  – TCP connection establishment
  – Association establishment

• Common header information is not repeated
  – But reduction is negligible compared to pixel data size

• Reduced latency (delay) between storage requests

• Creates opportunity for inter-slice (3D) compression

• Extremely implementation-dependent
Dataset (attributes+pixels)
C-Store request
C-Store response (acknowledgement)
Association

Dataset (attributes+pixels)

C-Store request

C-Store response (acknowledgement)

Store, parse, check

UIDs

DB
Dataset (attributes+pixels)

C-Store request

C-Store response (acknowledgement)
CTA - 548x512x512 (275MB) File read/transfer/save (GB Ethernet)

1=DICOM, 2=DICOM, 3=HTTP

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tr>
<td>Multi Frame</td>
<td>11.14111111</td>
<td>14.86703704</td>
<td>13.07333333</td>
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<tr>
<td>Single Frame</td>
<td>16.905</td>
<td>17.97</td>
<td>23.42666667</td>
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</table>
Multi-frame compression

- Original CT and MR SOP Classes are single frame
  - Compression only possible within a single frame
  - Lossless - typically 3:1 or 4:1 for CT and MR
- Multi-frame objects
  - Opportunity to take advantage of redundancy between frames
  - Spatial redundancy - JPEG 2000 Part 2
    - Lossless gain modest, lossy gain more substantial
  - Motion prediction - MPEG-2 and others
  - New schemes - H.264/MPEG-4 Part 10
  - Entire dataset (e.g., 3D volume) or adjacent slabs
Single frame lossless compression
Lossless JPEG 2000 Compression (Alexis Tzannes, Aware, 2003)

<table>
<thead>
<tr>
<th>Slices in 3rd dimension</th>
<th>Compression Ratio</th>
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<tbody>
<tr>
<td>127x256x8 7.9MB</td>
<td>2.073490814</td>
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<td>2.415902141</td>
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<td>449x512x16 224MB</td>
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<tr>
<td>3.1</td>
<td></td>
</tr>
</tbody>
</table>

single 20 40 80 all
Lossy 3D JPEG 2000 Compression (Alexis Tzannes, Aware, 2003)

- Average pSNR (dB)
- Compression Ratio

- Part 2 All
- Part 2 80
- Part 2 40
- Part 2 20
- Part 1
2D JPEG 2000 0.625mm slices
Multi-frame compression performance reality check

- Lossless compression in 3D
  - Slight gain - 15 to 20% smaller than 2D

- Lossy compression in 3D
  - Modest gain - possibly 50% smaller than 2D
  - But - only relatively modest loss before noticeable
  - Perhaps (?) 16:1

- Siddiqui et al, SCAR 2004
  - Thinner slices compress poorly due to noise
  - 3D JPEG 2000 compression may be used to compensate
  - Suggest using JND rather than PSNR as a metric

- Need more experiments
  - Effect on observer performance unknown
But when?
NEMA Initiatives

• MR test tools, images and spectra available
• CT test tools and images developed
• Implementation testing & demonstration
  – June 2005 - SCAR demonstration
  – November 2005 - RSNA InfoRAD demonstration
• After SCAR, CT test tools and images released
NEMA & SCAR
Test & Demonstration
Purpose of the Test & Demonstration

- **Participants**
  - Test that it works
  - Identify problems and solutions

- **Other vendors**
  - Show what work needs to be done

- **Users**
  - Show that it works
  - Begin to show some of the benefits
    - Performance
    - Interoperability of new attributes, dimensions, applications, spectroscopy … testing of clinical scenarios
Not just MR & CT ...

- Need for new multi-frame PET object
  - Currently single slice
  - Much renewed interest in PET-CT fusion
  - First draft during SNM June 2005 meeting

- X-ray angiography now part of the standard
  - Support for digital detectors
  - New acquisition types

- Tomosynthesis/cone beam CT - new work
Conclusion

- New DICOM image and other objects to address new applications
- Greater interfunctionality for more complex clinical scenarios and applications
- Performance opportunities for large data volumes
- Compression opportunities