Understanding Digital Modalities: System Integration and Use

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Dicom

• Digital Imaging and Communications in Medicine
  • Part 3: Information Object Definitions
    • Image objects
    • Non-image objects
  • Dicom elements
    • Defines specific information about the object
    • Requires specific value representation (VR) for element
      • Structure/Format, Information order, etc.
    • Each element has a numeric Tag
      • Group Number followed by an Element Number
        • e.g. (0010,0020) = Patient ID
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Image Objects (26)

- CR - Computed Radiography
- CT - Computed Tomography
- MR - Magnetic Resonance
  - Enhanced MR
- NM - Nuclear medicine
- DX - Digital X Ray
- US - Ultrasound
  - MF - Multi-Frame
- SC - Secondary Capture
  - MF - Multi-Frame
  - SB - Single Bit
  - GB - Grayscale Byte
  - GW - Grayscale Word
  - TC - True Color
- XA - X Ray Angiography
- RF - X Ray Fluoroscopy
- RT - Radiation Therapy Image
- PET - Positron Emission Tomography
- DX - Digital Radiography
- MG - Digital Mammography
- IO - Digital Intra Oral
- VL - Visible Light
  - EN - Endoscopy
  - MC - Microscopic
  - SL - Slide
  - PH - Photographic

Non-Image Objects (33)

- ST - Stand Alone Object
- OV - Overlay
- CV - Curve
- Mod LUT - Modality look-up-table
- VOI LUT - Value-of-interest look-up-table
- PET CV - PET Curve
- Basic Study Description
- Gray Scale Presentation State
- Stored Print
- Enhanced MR
  - Spectroscopy
- Raw Data
- RT - Radiation Therapy
  - Dose
  - Structure
  - Plan
  - Beam Record
  - Brachy Record
  - Sum
- WF - Waveform
  - Basic Voice Audio
  - 12 Lead ECG
  - General ECG
  - Ambulatory ECG
  - Homodynamic
  - Basic Card EP
- SR - Structured Report
  - Basic Text
  - Enhanced
  - Comprehensive
  - Key Object Selection
  - Mammography CAD
  - Chest CAD
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• All PACS vendors have the ability to view Dicom information

• Information utilization:
  • Determine acquisition system and location
  • Radiographic technique QA
  • Dose determination
  • Setup display annotations
  • Verify acquisition or processing parameters used

• Private Tags
  • Used for proprietary or vendor specific information
  • may not be visible
What Does a Physicist Need to Know

• What elements does the Modality use
  • Majority of elements are optional
    • Dicom committee knows more mandatory elements need to be included in future standard

• What elements can the PACS use
  • Many optional elements are not supported by PACS

• Is Modality supporting current and/or “retired” object standard
  • As technology and utilization changes, Dicom standard changes
CT/MR Object

- Developed over 10 years ago
- Defined viewing and annotation for “standard” series only
  - Advanced application elements are optional or non-existent
  - Processing information is stored in private tags only
- Increased data set sizes and hanging protocols not handled well, if at all
Dicom changes

• New objects include advanced features:
  • Multi-slice data
  • Mandatory acquisition parameters
  • Specialized data interchange and archiving
    • Raw data storage
    • Post processed data handling

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<th>MRI</th>
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Dicom Modality Worklist (DMWL)

Basic Worklist Management Service that supports the transfer of information for scheduled studies from Radiology Information System to Modality.

- **MWL Elements (over 50)**
  - (0040,0002) Scheduled Procedure Step Start Date
  - (0040,0003) Scheduled Procedure Step Start Time
  - (0040,0007) Scheduled Procedure Step Description
  - (0008,0050) Accession Number
  - (0010,0010) Patient’s Name, last^first
  - (0010,0020) Patient ID
  - (0008,0060) Modality
  - (0040,0006) Scheduled Performing Phys. Name
Workflow - Pre PACS

Information Management
1. RIS Scheduled Study
2. RIS Forms Print
3. Study Folder Prep.

Patient Management
4. Obtain Patient
5. Position Patient
6. Acquire Image
7. ? repeats
8. Select, window and print images
9. Submit for processing
10. Reload Cassettes
11. Review Films
12. RIS exam complete

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Workflow - Fully Functional PACS

Information Management
1. RIS Scheduled Study
   - RIS Forms Print
   - Study Folder Prep.
   - File & send folder
   - RIS exam complete

Patient Management
2. Obtain Patient
   - Modal. Worklist
   - Position Patient
   - Acquire Image
   - ? repeats
   - Performed Procedure Step
   - Select, window and print images

Image Processing
5. Submit for processing
   - Reload Cassettes
   - Review Images

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Scheduled Procedure Step Description

• Institution generated description of study
• Purpose of this attribute is to store a description or classification that is used at a local level
  • This description need not comply to an accepted standard
  • Can allow integration of x-ray generator control to be preset for scheduled exams/views
  • Requires programming on Modality to register technical parameters for all studies that may be scheduled
Utilization by Modality

• For each study received from MWL an icon or listing of each ordered view is displayed
  • e.g. AP and Lat
• For each listed view the appropriate technique is automatically set:
  • kVp
  • mA
  • timed/AEC
  • Grid required
    (e.g. reminder displayed)
Recommendations

• Insist on implementing MWL services on all modalities
• Carefully examine the query parameters in relationship to MWL database server
• Workflow improvements can be achieved by implementing Performed Procedure Step (PPS) and other features included in the standard
  • e.g. Scheduled Procedure Step Description

Virtually all Modality suppliers support MWL! However, support for other attributes such as PPS and other features are limited.
Image storage and display

- Modalities may acquire, locally store and send data differently
  - Raw and processed
  - Processed only
- For CR/DX Objects values sent can be varied
  - 8 - 12 bit
  - Optical Density (OD)
  - Presentation values (P-values)
  - Log (exposure)
**Image VOI**

- CR/DX modalities process ‘raw’ values and convert them into “log(exposure) space”
- Then for a specific value of interest (VOI) range, log(exposure) values are converted to OD or P values using a Look Up Table (LUT)
**OD values ➔ Film**

Image presentation values intended for film are printed to optical densities from 0 to 3.0 (+base)
OD values presented on a softcopy display have a luminance ratio of ~350 (i.e. OD range of 2.5)
OD values ➔ Softcopy

To allow OD values presented on a softcopy display to have a similar appearance to film window and level functions are used.

Image Value Log(luminance) 1 to 350 cd/m²
**OD values ➔ Softcopy**

To see the dark regions of the image the window level is changed.

![Diagram showing OD values and their corresponding log(luminance) values for different image values ranging from 1 to 350 cd/m².](image-url)
Luminance response – softcopy vs. film

- OD values sent to film printer produce a luminance response with log(luminance) proportional to image value.
- DICOM calibrated softcopy display characteristics produce a response with increased contrast in darker portions of image.
- Therefore, OD values sent to a calibrated softcopy display produce increased brightness and decreased contrast in darker regions of the image.

![Graph showing luminance response comparison between softcopy and film.](image)
Recommendations

- Modalities should be configured to send OD values to a printer and P values to PACS to produce equivalent appearance
The DICOM VOI LUT sequence

- Configuring CR/DX modality to send VOI/LUT removes the need for applying VOI and "removing" acquired information.
- Requires PACS to apply and vary the VOI/LUT on the softcopy display workstation in real time.
Using VOI/LUT with PACS

- PACS workstations should be capable of translating or stretching the VOI/LUT to make contrast and brightness changes.
Recommendations

- Calibrate monitors using a DICOM grayscale with a specified luminance ratio (~350)
- Configure your modalities and PACS to send and receive VOI/LUT sequences

However, many reputable CR/DX suppliers have not released software support for P-values and many reputable PACS suppliers do provide functions to shift and stretch VOI/LUT sequences!
More Information

• AAPM 2004 Continuing Education
  • Dicom Definitions and Testing - Monday 8:30 rm 303
  • Digital Image Management Systems - Tuesday 7:30 rm 317
• RSNA 2004 Refresher Courses
  • x53: Advanced PACS: How to Configure and Tune a PACS
  • 726: A Survival Guide to Quality Control for PACS
• SCAR
• SPIE