Program

- Monday:
  - The Role of the Physicist in the Planning and Design of Digital Image Management Systems
    - D Peck and M Flynn, Henry Ford Health System
- Tuesday:
  - Characteristics and Performance Evaluation of Digital Image Displays
    - H Roehrig, University of Arizona
- Wednesday:
  - Digital Image Processing in Radiography
    - D Foos, X Wang, Kodak Research Laboratories
- Thursday:
  - Design and Performance Characteristics of Digital Radiographic Receptors
    - J Seibert, UC Davis Medical Center

1

The Role of the Physicist in the Planning and Design of Digital Image Management Systems

Donald Peck, PhD
and
Michael Flynn, PhD

Outline

- Part 1
  - Digital image acquisition/modality options
  - Modality integration
- Part 2
  - Bandwidth and storage requirements
  - Softcopy viewing requirements
  - Performance/QA monitors

3

Modality Options

- Similar diagnosis can be done using different modalities
  - Plane X-Ray/CT
  - Mammography/US/MRI
- All imaging studies can be done utilizing a digital acquisition system
- Many studies can be performed using different detector systems
  - Storage Phosphor/Direct

4

Modality Requirements

- Acquisition requirements
  - Spatial and Temporal resolution
- Backup/redundant systems
  - Multiple cassette based systems vs. single direct radiography
- Workflow
  - Can all views be obtained with the detector?
    - Positioning, detector size, grid usage, etc.
  - Direct radiography may allow increased productivity
- Costs

5

Modality Installation

- Site planning
  - Shielding, HVAC, power, etc.
  - Network
    - # drops, bandwidth from modality, switch settings, etc.
- Communication standard
  - HL7
    - Primarily between HIS and RIS
  - Dicom

6

Dicom

- Part 3: Information Object Definitions
  - Image objects
  - Non-image objects
- Dicom elements
  - Defines specific information about the object
    - Information stored in "Tags"
  - Requires specific value representation (VR)
    - Structure/Format, Information order, etc.

7

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

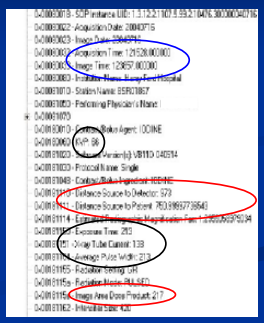
Non-Image Objects (33)

- 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

8

Dicom Header

- 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 Modality populate?
  - Majority of elements are optional
    - Dicom committee knows more mandatory elements need to be included in future standard
- What elements can PACS use?
  - Many optional elements are not supported by PACS
- Is Modality supporting current and/or "retired" object standard?

Example: CT/MR Object

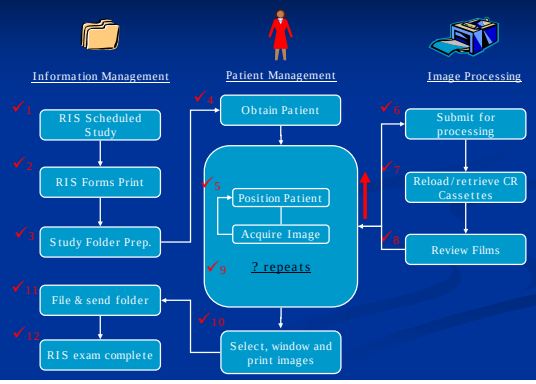
- Originally developed over 10 years ago
- New objects include advanced features:
  - Multi-slice data
  - Specialized data interchange and archiving
    - Raw data storage
    - Post processed data handling

	CT		MRI	
	Total Elements	Mandatory Elements	Total Elements	Mandatory Elements
Original Standard	18	0	44	2
New Standard	41	39	103	94

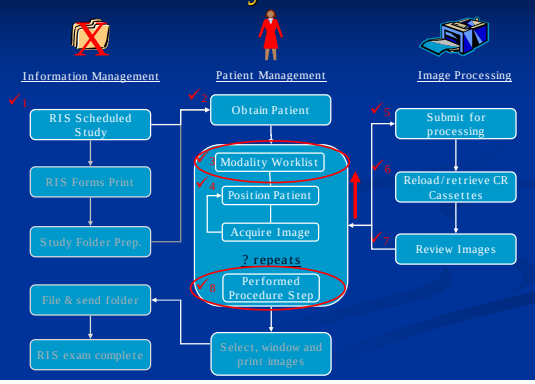
Dicom Modality Worklist (DMWL)

- Defines transfer of information from Radiology Information System (RIS) to Modality
- DMWL 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
  - (0010,0020) Patient ID
  - (0008,0060) Modality

Workflow – Pre PACS



Workflow – Fully Functional PACS



New Features

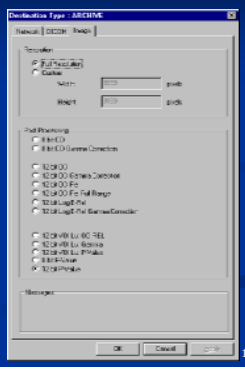
- Scheduled Procedure Step Description
  - Institution generated description of study
- Stores a description or classification that is used at a local level
  - Can allow integration of x-ray generator control to be preset for scheduled exams/views

Utilization by Modality

- For each study received from DMWL 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
  - time/AEC

Image Storage and Display

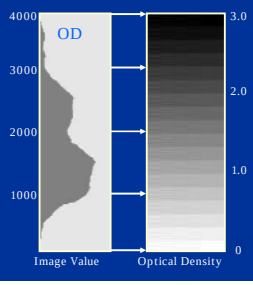
- Modalities may acquire, locally store and send data differently
  - Raw – "For Processing"
  - Processed - "For Presentation"
- For CR/DX Objects, values sent can be varied
  - 8 – 12 bit
  - Optical Density (OD)
  - Presentation values (P-values)
  - Log (exposure)

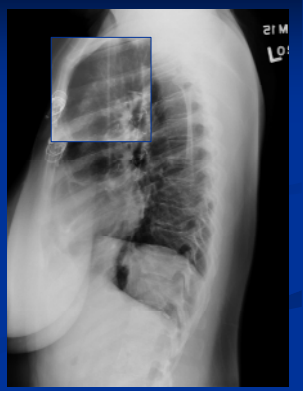


17

OD values ➔ Film

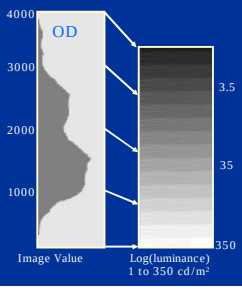
Image values intended for film are printed to optical densities





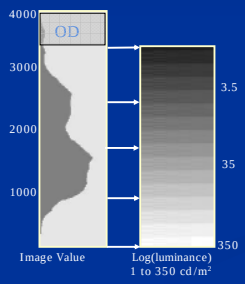
OD values ➔ Softcopy

OD values presented on a softcopy display have a luminance ratio of ~350



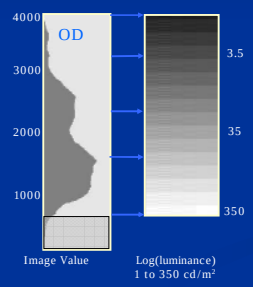
OD values ➔ Softcopy

To allow OD values presented on a softcopy display to have a similar appearance to film, window/level must be used



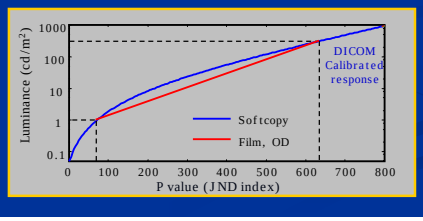
OD values ➔ Softcopy

To see dark regions of image the window level can be changed



Luminance response softcopy vs. film

- OD values sent to film produce a luminance response with log(luminance) proportional to image value
- DICOM calibrated display characteristics produce a response with increased contrast in darker portions of image



OD values sent to a calibrated display produce increased brightness and decreased contrast in darker regions

22

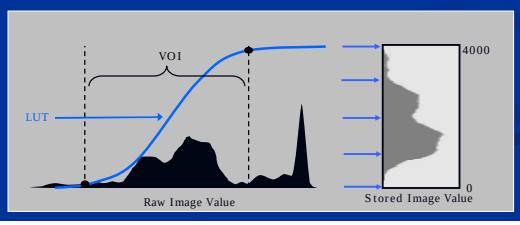
Modality Output

- Modalities should be configured to send OD values to a printer and P-values to PACS
- If printing is done by PACS only, modalities should be setup to send P-values only
  - PACS needs to send OD values to printer
  - Printers may be able to take P-values and map these to OD values prior to printing

23

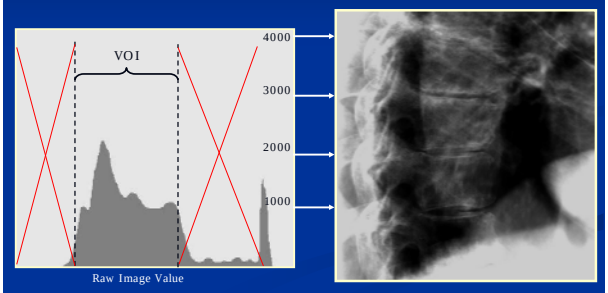
Image VOI (CR/DX Objects)

- Image processing algorithms determine specific value of interest (VOI) range for data of interest
- Log (exposure) values are converted to OD or P values using a Look Up Table (LUT)



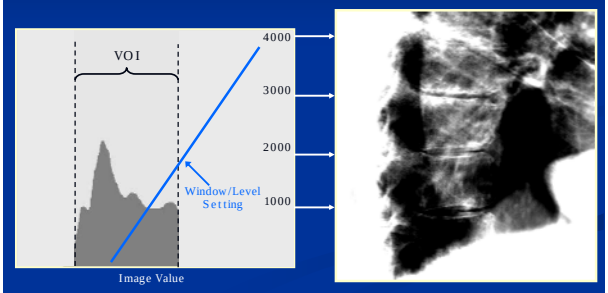
24

Application of VOI/LUT



25

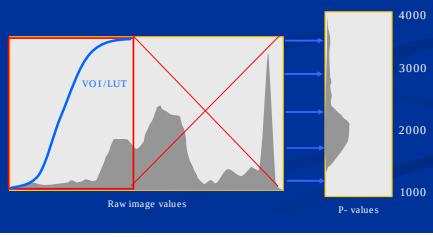
Window/Level with pre-set VOI/LUT



26

The DICOM VOI LUT sequence

- Instead of storing data after VOI/LUT is applied, modality "may" be able to send Presentation Values and VOI/LUT information in Dicom Header



27

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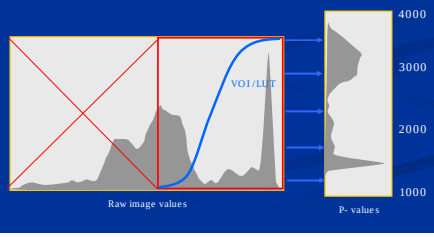
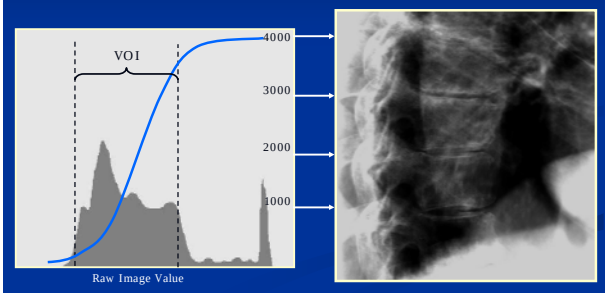


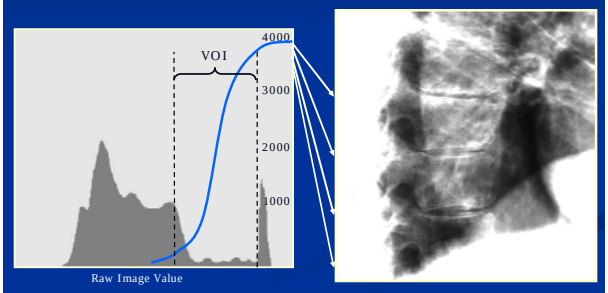
28

Application of VOI/LUT



29

Using VOI/LUT



30

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

31