Section I - Chapter 1
Digital Radiography:
An Overview of the Text

RADT 3463 Computerized Imaging

ASRT Leadership Development

http://www.asrt.org/events-and-conferences/student-leadership-development-program

https://www.surveymonkey.com/r/GQ5MPHQ

Deadline is December 19th

Texting (SMS) & Telegraph (Morse Code)
Film/Screen Radiography vs Filmless Imaging / Digital Imaging

### Digital Radiography: A Definition

- Detectors measure x-ray attenuation data from the patient.
- The data is then converted into electronic (analog) signals.
- The analog signals are converted into digital data for computer processing.

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Digital imaging systems are used in:
- Image storage
- Information management systems
- Image and data communications

What are the steps in Film-Based Radiography?

**Film-Based Radiography: A Brief Review**

**Basic Steps in the Production of a Radiograph**

Density results from the amount of exposure and anatomic attenuation in an image:
- Higher mAs = more dense (overexposed)
- Lower mAs = less dense (underexposed).
Contrast is the differences in image densities.

- Higher kVp = Long scale = more gray shades
  - Low contrast
- Lower kVp = Short scale = fewer gray shades
  - High contrast

Optical Density (OD)

- The measurement of the amount of light transmitted through the film
- Describes the degree of film blackening as a result of radiation exposure
- Can be measured by a densitometer.

X-ray film through chemical processing converts the transmitted radiation by the various types of tissues (tissue contrast) into film contrast.

Characteristic Curve or the Hurter-Driffield (H and D) curve describes film contrast.

- The curve is a plot of the OD to the logarithm of the relative exposure (radiation exposure) to make the radiograph.
The curve indicates the degree of contrast (different densities) that a film can display using a range of exposures.

The curve has three main segments:
- Toe
- Slope (straight-line portion)
- Shoulder.

Two other factors that can be described using the characteristic curve:
- Film Speed
- Film Latitude

Film Speed
- Sensitivity of film to radiation
- Fast film (speed) = less exposure
- Slow film (speed) = more exposure
**Film-Based Radiography: A Brief Review**

**The Film Characteristic Curve**

**Film Latitude**
- Wide exposure latitude = ability to use a wide range of exposures
- Narrow exposure latitude means it respond to small range of exposures.

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**A Digital Radiographic Imaging System: Major Components**

- Data Acquisition
- Computer Data Processing
- Image Display and Post Processing
- Image Storage
- Image and Data Communications
- Image and Informational Management

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**A Digital Radiographic Imaging System: Major Components**

**Image Storage**
- Image are archived and stored for retrospective analysis and for medico-legal purposes.
  - **Old** Standard of Optical
    - CD
    - DVD
    - Permanent Hard Drive
  - **New** Plug and Play Entries
    - Flash Memory / Memory Cards
    - USB Jump drive
    - Portable hard drives
A Digital Radiographic Imaging System: Major Components

- **IMAGE STORAGE**
  - Long term storage of digital images needs to rely on large capacity servers such as a RAID (redundant array of independent disks) system.
  - Short-term archival systems are deleted after a period of time defined by the institution.

<table>
<thead>
<tr>
<th>Medical Image</th>
<th>Image Size</th>
<th>Examination Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Medicine</td>
<td>0.25 MB</td>
<td>5 MB</td>
</tr>
<tr>
<td>Diagnostic Sonography</td>
<td>0.25 MB</td>
<td>8 MB</td>
</tr>
<tr>
<td>Magnetic Resonance Imaging</td>
<td>0.25 MB</td>
<td>12 MB</td>
</tr>
<tr>
<td>Computed tomography</td>
<td>0.5 MB</td>
<td>20 MB</td>
</tr>
<tr>
<td>Digital Radiography</td>
<td>5 MB</td>
<td>20 MB</td>
</tr>
<tr>
<td>Digital Mammography</td>
<td>10 MB</td>
<td>60 MB</td>
</tr>
</tbody>
</table>

- **IMAGE AND DATA COMMUNICATIONS**
  - **Image Compression**
    - Storing data in a format that requires less space than usual.
    - Compression techniques are distinguished by whether they remove detail and color from the image.
    - Crucial to radiology and teleradiology because of large image file sizes.
    - The process of compacting an image by removing redundant information.

- **Lossless Compression**
  - On decompression, the original is restored in every detail.
- **Lossy (lossy) compression**
  - Unnecessary detail is thrown away.

Images need to be transmitted from the acquisition phase to the display/viewing and storage phase.

- PACS - Picture Archiving and Communication Systems store and archive images.
- RIS - Radiology Information Systems can use PACS systems are being used for storing/archiving and communicating images.
- HIS - Hospital Information System are now being integrated with the PACS by computer networks.
A DIGITAL RADIOGRAPHIC IMAGING SYSTEM: MAJOR COMPONENTS

- **IMAGE AND DATA COMMUNICATIONS**
  - **LANS** - local area networks can be used within a hospital.
  - **WANS** - wide area networks are used for sites outside and remote of the hospital.
  - Effective management and standards of patient information
    - **DICOM** - Digital Imaging and Communications in Medicine and
    - **HL-7 Health Level-7**

- **IMAGE AND INFORMATION MANAGEMENT**

  Managing information and images is performed with:
  - **PACS** = imaging examinations
  - **RIS** = holds all radiology-specific patient data from the patient scheduling information to the radiologist’s dictated and transcribed report.
  - **HIS** = holds the patient’s full medical information from hospital billing to the inpatient ordering system.

INTEGRATING THE HEALTH CARE ENTERPRISE

- A model for ensuring that the standards for communication work effectively to facilitate integration
  - **DICOM** and **HL-7**
  - **ACR, RSNA, and HIMSS** developed the Technical Framework
Digital Radiography Modalities

- Computed Radiography
- Flat-Panel Display Radiography
- Digital Mammography
- Digital Fluoroscopy

Digital Radiography Modalities ⇒ Computed Radiography (CR)

Fundamental steps in the production of a CR image.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X-ray tube</td>
</tr>
<tr>
<td>2</td>
<td>CR detector or imaging plate</td>
</tr>
<tr>
<td>3</td>
<td>Light collection</td>
</tr>
<tr>
<td>4</td>
<td>Charge-coupled devices (CCDs)</td>
</tr>
<tr>
<td>5</td>
<td>Digital processor</td>
</tr>
<tr>
<td>6</td>
<td>(Optional) - Another exposure</td>
</tr>
<tr>
<td>7</td>
<td>CR image reader/processor</td>
</tr>
</tbody>
</table>

Digital Radiography Modalities ⇒ Flat-Panel Digital Radiography

- Digital detector is designed as a flat-panel
- Two Categories
- Indirect conversion digital radiography systems
  1. Array of electronic elements
  2. Charge-coupled devices (CCDs)
- Direct conversion digital radiography systems

Indirect (electronic elements)

- X-rays are converted to light using a phosphor such as cesium iodide.
- Emitted light from the phosphor falls on a matrix array of electronic elements to create and store electrical charges in direct proportion to X-ray exposure.
- Charges produce electrical signals, which are digitized to produce an image.
**Digital Radiography Modalities**

**Direct (Flat-Panels)**

- Detectors convert x-rays directly into electrical signals.
- X-rays fall on a photoconductor (e.g., selenium) that is coupled to a matrix array of electronic elements to produce electrical signals.
- These signals are digitized and processed to produce an image.

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**Indirect (Charge-Coupled Devices)**

- Uses an array of charge-coupled devices (CCDs) which are coupled to a scintillator phosphor, cesium iodide.
- X-rays fall on the phosphor to produce light, which then falls on the CCD array, which in turn converts the light into electrical signals that are then digitized and processed to produce an image.

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**Advantages**

- Flat-panel digital detector can be erased and ready to be reused.
- High detective quantum efficiency (DQE).
- Spatial resolution comparable to CR systems.
- Characteristic response to radiation exposure with wide exposure latitude fundamentally different to the film characteristic curve.
- Wide exposure latitude will produce acceptable images even when the input exposure is low or high.
**Digital Radiography Modalities**

**Digital Mammography**

**Benefits**
- Overcomes limitations of technique in film-screen mammography
- Post-processing tools allows enhancement image for interpretation
- Uses computer-aided diagnosis (CAD) software to enhance detection of microcalcifications and malignant lesions
  - Provides the "second reader"

**Digital Fluoroscopy**

**Major goal of digital fluoroscopy**
- Use digital imaging processing software to improve the perception of contrast resolution, compared to conventional fluoroscopy

**Advantages**
- Gray-scale processing
- Temporal frame averaging
- Edge enhancement
- Produces dynamic images acquired in real time

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**Digital Radiography Modalities**

**Digital Fluoroscopy**

**Application**
- Digital subtraction angiography (DSA) in which pre-contrast and post-contrast images can be digitally subtracted in real time.
  - Why? Improve the perception of low-contrast vessels by subtracting or removing the tissues (bones) that interfere with visualization of vascular structures.
- Two subtraction techniques
  - Temporal subtraction
  - Energy subtraction
Temporal subtraction, in which images are subtracted in time

Energy subtraction, in which images are subtracted using different kilovoltages.

A comprehensive computer system responsible for the
Electronic storage and distribution of medical images in the medical enterprise
The system is highly integrated with digital acquisition and display devices
The system is often related closely to other medical information systems, such as:
  - Radiology Information System (RIS) or
  - Hospital Information System (HIS)
Major components include:
- Image acquisition devices
- PACS computer
- Devices called interfaces
- Display workstations
- All should be connected and linked to HIS and RIS

Two standards used in a PACS environment
- DICOM
  - Concerned primarily with images from the digital image acquisition modalities
- HL-7
  - Concerned mainly with textual information from the HIS and RIS.

PACS systems contains confidential patient data and information
- Data security is of central importance (HIPPA)
- Interfaces
  - Facilitate easy communication between the image acquisition modalities and the HIS/RIS with the PACS computer
  - Allow individuals to use the World Wide Web to access the PACS computer.

QA and QC procedures are effective strategies to ensure continuous quality improvement to:
- Ensure patients are exposed to minimum radiation using the ALARA (as low as reasonably achievable) philosophy.
- Produce optimum image quality for diagnosis.
- Reduce the costs of radiology operations.
**Medical Imaging Informatics**

- What is Medical Imaging Informatics
- The Technologist as Informaticist

Information Technology (IT) concepts are used for:
- Digital image acquisition technologies
- Digital image processing
- Digital image display
- Storage and archiving
- Digital image communications
- Rapidly growing field – degrees in informatics

**What is Medical Imaging Informatics**

IT helps use images for:
- Diagnosis
- Assessment and planning
- Guidance of procedures
- Communication
- Education
- Training
- Research.

**The Technologist as Informaticist**

- Radiographers need skills related to IT
- Radiology Departments need a PACS administrator (IT administrator)
  - Function is dedicated to ensuring the integrity of the PACS.
- Radiographers need to learn the skills to become a informaticist
SECOND LOOK:
Sprawls Educational Foundation
Film Contrast
http://www.sprawls.org/ppmi2/FILMCON

QUESTIONS??
What lies behind us and what lies before us are small matters compared to what lies within us.
Ralph Waldo Emerson