Imaging Informatics

Richard H. Wiggins, III, MD, CIIP, FSIIM
Department of Radiology, Otolaryngology, Head and Neck Surgery, and BioMedical Informatics
University of Utah Health Sciences Center
Salt Lake City, Utah

Imaging Informatics

• BioMedical Informatics
• Imaging Informatics
  – PACS
  – SR
  – RIS

Imaging Informatics

• Radiologist perspective
  – What is important to the radiologist?

Imaging Informatics

• Radiologist perspective
  – What is important to the radiologist?
  – What makes me more efficient?

• PACS?
• SR?
Imaging Informatics

• What is informatics?
  – The study of the processes involved in the collection, categorization, and distribution of data, particularly with reference to computer data

BioMedical Informatics

• What is informatics?
  – The study of the processes involved in the collection, categorization, and distribution of BioMedical data, particularly with reference to computer BioMedical data

BioMedical Informatics

Methods, Techniques, and Theories

Basic Research

Bio-informatics

Imaging Informatics

Clinical Informatics

Public Health Informatics

Applied Research

BioMedical Informatics

Methods, Techniques, and Theories

Basic Research

Bio-informatics

Imaging Informatics

Clinical Informatics

Public Health Informatics

Applied Research

Imaging Informatics

• Image generation
• Image management
• Image manipulation
• Image integration

Imaging Informatics

• Image generation
  – Generating the images
  – Digitizing if necessary

BioMedical Informatics

Methods, Techniques, and Theories

Basic Research

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BioMedical Informatics

Methods, Techniques, and Theories

Basic Research

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Clinical Informatics

Public Health Informatics

Applied Research
Imaging Informatics

- Image generation
- Image management
  - Storing
  - Transmitting
  - Displaying
  - Retrieving
  - Organizing

Radiologic Process

- Clinician desires radiologic study
- Procedure requested and scheduled
- Procedure performed
- Radiologist reviews images
- Radiologist creates report
- Quality control and workflow monitoring
- Continuing education and training
Program was developed using the SIIM core knowledge domains

- Analytics: Leveraging clinical and operational data
- Enterprise Imaging: Digital image management with a strategic enterprise perspective
- Productivity and Workflow: Next generation medical imaging workflow to improve efficiency and cost
- Quality: Harnessing information for better patient and inter-departmental care

Imaging Informatics

- Image generation
- Image management
- Image manipulation
- Image integration

X-Rays

- Discovered in 1895
  - Wilhelm Conrad Roentgen
  - Current caused fluorescent screen to glow
- Similar to light and radio waves
  - Electromagnetic radiation
  - High energy and short wavelength
  - Energy blocked by dense tissue
  - Bones - less energy passes through - white
  - Lungs - more energy passes through - black

Modalities

- Plain Film
  - Conventional Tomography
  - Fluoroscopy
  - Angiography
- Cross-sectional imaging
  - CT
  - MRI
  - USG
  - Nuclear medicine

Imaging Informatics

- Neuroradiology
- Cardiothoracic
- Gastrointestinal
- Genitourinary
- Ultrasound
- Musculoskeletal
- Pediatrics
- Interventional
- Woman's imaging
- Nuclear medicine
Plain Film Radiography

• Computed radiography
  – 2048 X 2560
  – 12 Bits / pixel
  – 2 Bytes / pixel
  – 10.5 MB / image

Radiology Modalities

• Digital Mammography
  – 3000 X 3000
  – 16 Bits / pixel
  – 2 Bytes / pixel
  – 20 - 40 MB / image

Radiology Modalities

• Digital Fluoroscopy
  – 1024 X 1024
  – 8 Bits / pixel
  – 1 Bytes / pixel
  – 1 MB / image

Imaging Modalities

• Digital subtraction angiography (DSA)
  – 1024 X 1024
  – 8 Bits / pixel
  – 1 Bytes / pixel
  – 1 MB / image

Reconstruction Methods

• Angiography – 1923
  – Digital subtraction angiography (DSA)
Reconstruction Methods

- **Computed Tomography** – 1974
  - Hours to acquire a slice
  - Days to reconstruct a single image

Radiology Modalities

- **Computed tomography (CT)**
  - 512 x 512
  - 12 Bits / pixel
  - 2 Bytes / pixel
  - 0.5 MB / image

Radiology Modality

- **Magnetic resonance imaging (MRI)**
  - Intense, uniform magnetic field

Radiology Modality

- **Magnetic resonance imaging (MRI)**
  - Radiofrequency pulse
  - Nuclei return to original state
  - Emit detectable radiofrequency signal

Radiology Modality

- **Magnetic resonance imaging (MRI)**
  - 512 x 512
  - 16 Bits / pixel
  - 2 Bytes / pixel
  - 0.5 MB / image

Radiology Modality

- **Nuclear Medicine**
  - Radioactive isotope chemically attached to biologically active compound
Radiology Modality

- Nuclear Medicine
  - 128 X 128
  - 8 Bits / pixel
  - 1 Byte / pixel
  - 0.016 MB / image

- Ultrasound
  - Echosonography
  - High-frequency waves
  - 2D images

Higher Dimensionality

- Ultrasound
  - 3D images

Image Parameters

<table>
<thead>
<tr>
<th>Modality</th>
<th>Pixels</th>
<th>Bytes/Pixel</th>
<th>Images/Study</th>
<th>Data/Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR</td>
<td>2048 X 2560</td>
<td>2</td>
<td>3</td>
<td>31.4 MB</td>
</tr>
<tr>
<td>CT</td>
<td>512 X 512</td>
<td>2</td>
<td>100</td>
<td>52 MB</td>
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<tr>
<td>MRI</td>
<td>512 X 512</td>
<td>2</td>
<td>300</td>
<td>157 MB</td>
</tr>
<tr>
<td>USG</td>
<td>512 X 512</td>
<td>1</td>
<td>30</td>
<td>8 MB</td>
</tr>
<tr>
<td>NM</td>
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<td>1</td>
<td>30</td>
<td>0.5 MB</td>
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</table>
### Image Parameters

<table>
<thead>
<tr>
<th>Modality</th>
<th>Radiation</th>
<th>Portability</th>
<th>Physiology</th>
<th>Cost</th>
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<td>CR</td>
<td>Moderate</td>
<td>Moderate</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>CT</td>
<td>Moderate</td>
<td>No</td>
<td>No (Yes)</td>
<td>High</td>
</tr>
<tr>
<td>MRI</td>
<td>None</td>
<td>No (Low)</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>USG</td>
<td>None</td>
<td>High</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>NM</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Yes</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

### Changes in Radiology?

- Data overload
  - How many images reviewed per study?
    - 1994 – 1,500 images/day
    - 2002 – 16,000 images/day
    - 2006 – 80,000 images/day

### Imaging Informatics

- BioMedical Informatics
- Imaging Informatics
  - PACS
  - SR
  - RIS

### Image Management

- Environmental Design for Viewing and Interpreting Images
- The Human Computer Interface
- Work Flow Processes that Ensure Data Integrity
- Import and Export Images
Environmental Design for Viewing and Interpreting Images

- Ergonomics
- Environmental factors
- Room layout physical considerations

Ergonomics

- Good working positions
  - Neutral body positioning
    - Joints are naturally aligned
    - Reduces stress and strain
    - Reduces risk of musculoskeletal disorder

https://www.osha.gov/SLTC/etools/computerworkstations/

Environmental Factors

- Lighting problems
- Glare problems
- Ventilation problems
**Environmental Factors**

- **Lighting problems:**
  - Bright lights shining on PACS monitors washes out images and increases eye strain
  - Solutions:
    - Place lights parallel to line of sight
    - Install light diffusers
    - Supplemental light sources
      - CRT displays: 20 - 50 foot-candles of light
      - LCD monitors: 50 – 70 foot-candles of light

- **Lighting problems:**
  - Bright light sources behind PACS monitors creates contrast problems
  - Solutions:
    - Blinds or drapes to eliminate bright outside light
      - Horizontal blinds for north/south windows
    - Vertical blinds for east/west windows

**Image Management**

- Environmental Design for Viewing and Interpreting Images
- The Human Computer Interface
- Work Flow Processes that Ensure Data Integrity
- Import and Export Images

**The Human Computer Interface**

- EMR/RIS/PACS/SR
- Usability
- Key image selection and image annotation
- Input devices
- Display devices
PACS

- Picture Archival and Communications System

PACS

- Picture
  - All types of medical images
- Archival
  - Short and long term storage with rapid retrieval
- Communications
  - Sending data between devices
- Systems
  - Multiple networked devices

PACS

- Components
  - Acquisition devices
    - CT, MRI, USG, digitizers
  - Networks
  - Display devices (monitors)
  - Storage devices (archives, servers)
- Standards
  - Platforms and communication
    - DICOM, HL-7

PACS

- Easier interpretation and comparison of studies
- Faster and more accurate diagnosis for patients
- Immediate access from any location to comprehensive images and reports
- Enhanced patient safety through process automation
- Facilitation of timely remote peer consultation
- Higher radiology productivity

PACS

- Fewer patient exam delays
- Better report turnaround time
- Improved patient/physician satisfaction
- Images enhanced and transmitted more easily
- Reduction in lost or misplaced films
- Lower film and chemical costs
- Decreased film storage space requirements
U of U PACS History

- Decreased film printing costs:
  - 10/00 – 12/00: $3.45/exam
  - 7/02 – 9/02: $0.81/exam

- Increased technologist productivity:
  - 10/00 – 12/00: 434 exams/technologist FTE
  - 7/02 – 9/02: 575 exams/technologist FTE

- Decreased number of Radiology personnel:
  - 7/00 – 9/00: 16
  - 7/02 – 9/02: 9

- Decreased radiology report time turn around:
  - 7/00 – 9/00: 41.4 hours
  - 10/01 – 12/01: 9.6 hours

- Decreased inpatient throughput:
  - 7/00 – 9/00: 16.1 hours
  - 1/02 – 3/02: 7.9 hours

- Increased Radiologists productivity:
  - 7/00 – 9/00: 1,493 RVU/radiologist FTE
  - 7/02 – 9/02: 1,811 RVU/radiologist FTE
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Standard Scanning Protocols - Multi-slice CT Scanner

<table>
<thead>
<tr>
<th>Studies/ Month</th>
<th>Avg # Slices/ Study</th>
<th>Avg MB/Study</th>
<th>Compression Lossless (2:1)</th>
<th>Total Storage/Month (MB)</th>
<th>Total Storage/Yr</th>
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<tbody>
<tr>
<td>2,000</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>100,000</td>
<td>1,200,000</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>100 GB / Month</td>
<td>1.2 TB/year</td>
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</table>

Advanced Scanning Protocols - 64 Slice CT Scanner

<table>
<thead>
<tr>
<th>Studies/ Month</th>
<th>Avg # Slices/ Study</th>
<th>Avg MB/Study</th>
<th>Compression Lossless (2:1)</th>
<th>Total Storage/Month (MB)</th>
<th>Total Storage/Yr</th>
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</thead>
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<tr>
<td>2,000</td>
<td>1,500</td>
<td>750</td>
<td>375</td>
<td>750,000</td>
<td>9,000,000</td>
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<td></td>
<td></td>
<td></td>
<td>750 GB (750 GB / Mo)</td>
<td>9 TB/year</td>
<td></td>
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</table>

U of U PACS History

- 2001 – Marconi bought by Philips
  - Assumed service component of contract
- 2001 - GEMS bought Applicare
  - Future development on RadWorks?
- Still had 3 yrs on the Fee/Use contract

U of U PACS Future Options

- PACS Shopping
  - A.L.I. Technologies UltraPACS (McKesson)
  - GE Centricity
  - Philips Inturis
  - Agfa IMPAX
  - Siemens MagicView
  - DR Systems
  - Fuji Synapse
  - Kodak
  - Canon
  - eMed Technologies Ideal
  - Stentor iSite

U of U PACS Future Options

- Other?

- PACS expenditures
  - 1999 $468 million
  - 2000 $663 million
  - 2001 $840 million
- PACS market
  - 2000 $421 million
  - 2007 $1.1 billion
U of U PACS Future Options

Criteria used for the search:
- Well established company with expertise in large hospital settings
- Single vendor that could fulfill all medical imaging needs for the enterprise
- Vendor not likely to get bought or go out of business
- Technology must be cutting edge
- Comply with HL7, DICOM & IHE standards
- Open architecture, standard equipment

PACS Transition

- "PACS customer and PACS vendor relationship is like a marriage"
- No!, after marriage, you can get a divorce
  - Not so with PACS databases

What Happened?

- “Filmless” hospitals
  - In 2001, reported that only 1% of hospitals were truly filmless
  - 2006 Outpatient centers passes 25%
- Paperless

PACS Transition Facts

- >2000 institutions with PACS over 2 years old
- PACS likely has a lifespan of about 5-10 years
- Database migration will be key issue in second PACS purchases
  - Significant problems with
    - Upgrading
    - Replacing
    - Migration
    - Recycling

PACS Transition Issues

- PACS purchasing shifts from Radiology department to institutional ITS department
- PACS purchasers getting smarter, making demands on vendors
- Change from single vendor "turn-key" system, to custom individual systems

PACS Transition Reasons

- Older systems may not meet HIPAA, DICOM 3, HL-7, IHE standards/specifications
- Early PACS adopters may not have met their financial goals (economics)
- Increased functionality/scalability
- General "PACS problems"
PACS Transition Reasons

- “PACS is down”
  - “PACS is broken”
    - One of the three workstation monitors died
  - “Images won’t come up”
    - Trying to use outside CD with DICOM viewer on workstation
  - “Nothing works”
    - LCD projector in conference room died

- “PACS is down”
  - “Keyboard not working”
    - Fellow spilt egg drop soup on keyboard, and keys were sticking
  - “Colors are all wrong”
    - Resident needed to work on poster, so they loaded Adobe Illustrator on workstation
  - “Speech microphone is broken”
    - Resident tried to play new U2 audio CD on PACS workstation, and changed configuration of sound card, causing loud squeaking noise, leading the attending to rip the $1,000.00 speech mic out of the workstation

PACS Transition Problems

- PACS replacement
  - Can be as time consuming as original PACS deployment
- Requires knowledge in several areas
  - Networks
  - Archives
  - Database migration
  - Computer system interfaces
  - Project management

- PACS deployment
  - Assessment of needs
  - Planning/budgeting
  - Performance criteria
    - “99% uptime”

Imaging Informatics

- BioMedical Informatics
- Imaging Informatics
  - PACS
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