Digital Breast Tomosynthesis & the Informatics Infra-Structure

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Standards & Interoperability

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PixelMed Publishing

DBT Informatics Challenges

- Size
- Features
- Compatibility

- Projection Images
- Synthetic Images
- Workflow

Size

- FFDM images are large enough
- Breast Tomosynthesis images are huge
  - large matrix & high resolution (2 – 2.5 MP)
  - many slices, typically 50 – 100 per view
  - typically about 0.4 GB per image
  - 1 or 2 views per each of 2 breasts
  - i.e., 1 – 1.5 GB per study uncompressed
- Screening reads are performed rapidly
- High throughput
- Significant stress on infrastructure & workstation
- Compression is desirable

Size - Compression

- Faster to transmit
  - especially if stored that way on server
- Faster to load
  - especially if use simple, fast to decompress, method
- Less space
  - reduction in size in cache, archive, backups
- If lossless, why not?
  - takes time & resources to compress & decompress
  - interoperability issue (unusual/non-standard scheme)
- Lossy forbidden
  - for interpretation and retention, by MQSA in US

Hologic Only – Size MB - N=77

Scheme	CR mean	CR SD
JPEG lossless selection value 1	128.1	50.1
JPEG-LS	90.7	41.1
JPEG 2000 5x3 VM single frame	91.9	41.3
JPEG 2000 5x3 Aware single frame	91.8	41.3
JPEG 2000 5x3 Aware multi-component all frames	88.5	39.7
JPEG 2000 5x3 Aware multi-component 10 frame slab	89.1	40.0
Original uncompressed pixel data	621	201

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Hologic proprietary Secondary Capture Object (SCO)	51.0	23.3

Features

- DBT requires *ALL* standard FFDM features
  - hung and flipped correctly
  - laterality, view, orientation (from DBT attributes)
  - sizing (auto, true, 1:1), annotation, measurements
  - technique annotation
  - CAD marks
- DBT extras
  - rapid scrolling/cine in same window
  - multiple simultaneous cine (2/4 current+2/4 priors)
  - toggle between 2D/3D/synthetic
  - more technique annotation ? (slice#, # of slices, angles)
  - user annotations on frames, and alerting to their presence +/- projection onto synthetic views

Features – IHE Mammo Profile

- IHE Mammo Display Profile to address it
  - previous FFDM interoperability fiasco
  - response to SCAR Breast Forum 2005
  - display features using standard attributes
  - widely supported by modalities & PACS
- A new Mammo Tomo Display Profile?
  - all the features of MAMMO
  - rapid scroll/cine through tomo, etc.
  - distinguish Synthetic (MIP) images from FFDM
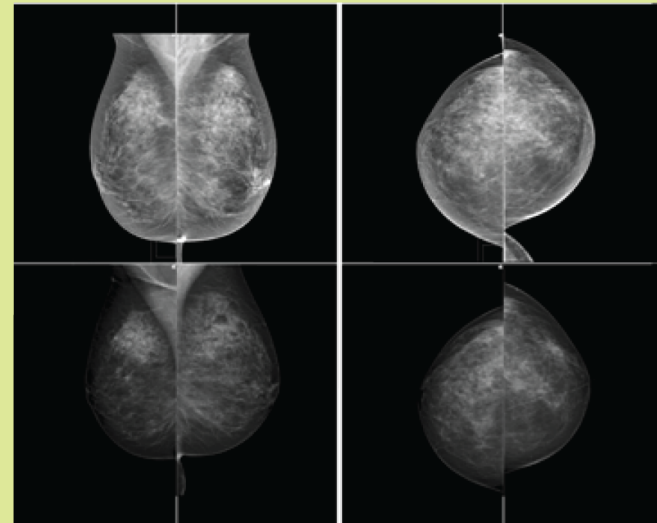 - ? projection images and tomo CAD?

IHE Mammo Profile

Non-IHE
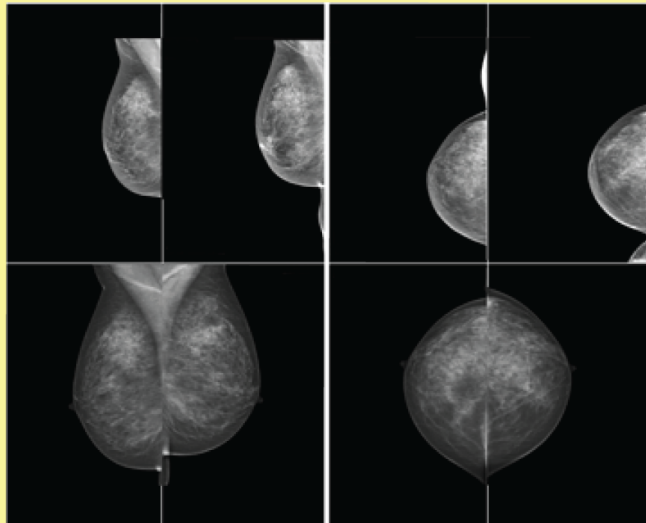
Prior (above) and Current (below) images are of different sizes and inconsistent orientation

IHE Mammo

Prior (above) and Current (below) images are of same size and consistent orientation
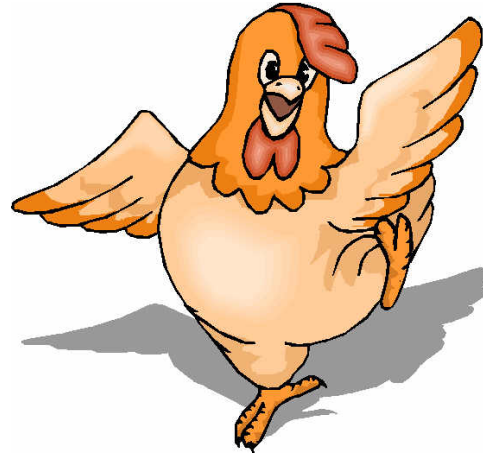
Compatibility

- Problem
  - new modality
  - multi-frame
  - large
  - limited PACS/archive/viewer new IOD support

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- Problem
  - new modality
  - multi-frame
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  - limited PACS/archive/viewer new IOD support
- Standard widely supported solution options
  - re-use (abuse) MG, CT (one slice per instance)
  - use multi-frame SC
  - use standard compression (lossless JPEG/J2K)
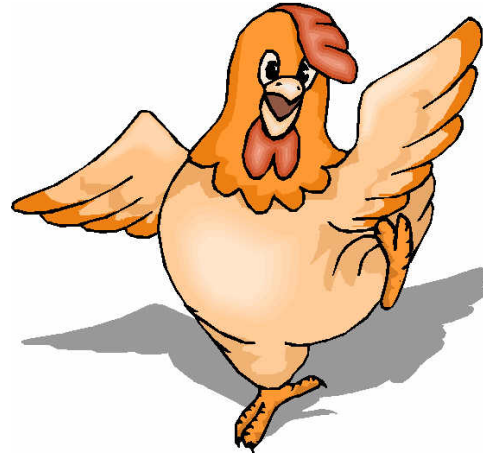
Breast Tomosynthesis IOD

- DICOM Sup 125, final text in August 2008
- Multi-frame MG object
  - enhanced multi-frame structure
  - based on 3D X-Ray design (consistent with angio)
  - re-uses technique attributes from MG
  - includes 3D CT/MR/PET-like position, orientation
- Many PACS added storage support in 2011
- Hologic modality did not support until 2012
- Hologic Europe CE 2008, USA FDA 2011
- IMS/Giotto – DICOM BTO from the start (? 2010)

Hologic SCO

Hologic SCO Abomination

- ## Secondary Capture Object
  - single frame meaningless pixel data
  - "real" pixel data hidden in private attributes
  - proprietary undisclosed compression scheme
- ## Like a parasite
  - "hidden" inside the host's body
  - storable but not viewable in PACS
  - interchangeable but not viewable on CD
  - are small (relatively speaking)

Hologic SCO Consequences

- An archive full of unviewable priors
  - need to be converted to standard BTO
  - Hologic refuses to distribute a conversion utility
  - Hologic refuses to disclose format
  - Hologic workstation cannot perform conversion
  - can't burn CDs with an SCO viewer on them
- BTO is now supported by Hologic modality
  - some sites still elect to acquire SCOs
  - PACS that doesn't support BTO
  - PACS that doesn't support JPEG lossless compression

Transition Strategies

- New DBT installation with BTO archiving PACS
  - acquire as BTO – no problem
- New DBT installation without BTO PACS
  - acquire as BTO – separate temporary archive or VNA
  - acquire as BTO – convert to standard MFSC pre-PACS
- Existing archive of SCO and PACS gets BTO
  - switch modalities to BTO, but read/view with priors only on Hologic workstation
  - convert – on demand, or migrate everything
  - conversion may result in two copies in PACS ☹

Multiframe Secondary Capture

- A standard fall back from BTO, with valid Pixel Data
  - configurable or during association negotiation
- Just change BTO SOP Class UID to MFSC
  - send all other attributes
  - can be changed back later
- From modality
  - directly (vendors have not yet done this)
  - 3rd party converter between modality & PACS
  - need to select compatible lossless compression scheme
- Other viewers receiving MFSC from PACS
  - detect MG in MFSC and display as if BTO

Latest Version of PACS?

- Informal survey - 23 respondents
- Only 5 (22%) reported current version in use
  - but 14 (61%) plan to deploy 3 months – 1 year
- 2 in more than 2 years, another 2 never
  - outsourced & supplier refuses; works so no need
  - does not include initial site: too much customized stuff dependent on old version
- 3 reported missing out on Mammo & DBT
- Vendors
  - 2 Agfa, 2 DR, 3 Fuji, 6 GE, 2 InteleRad, 2 McKesson, 2 Merge, 1 Philips, 2 Sectra, 1 Siemens

Projection Images

- Projection images
  - the "raw data" of tomo
  - potentially useful for CAD
  - some radiologists may want to review them
  - opportunity for 3rd party reconstruction algorithms
- Still no DICOM standard specifically for them
  - WG 15 is working on it, esp. 3D coordinate issues
  - again, standard compressed MFSC would be OK
  - Hologic uses the evil proprietary SC private data

Orientation and Layout

- DBT images are cross-sections
- CT/MR/PET-like 3D attributes in BTO
- NOT as simple as Patient Orientation letters
- Viewers need to translate 3D vector in Image Orientation (Patient) nested in Plane Orientation (Patient) functional group macro
- Otherwise images may be upside down, etc.
- Check with asymmetric phantom else won't notice

Synthetic Images

- E.g., MIP of slices to simulate FFDM
- Hologic C-View
  - just approved by FDA
  - CE mark since 2011
- Which DICOM SOP Class to encode them?
  - MG FOR PRESENTATION as DERIVED image would seem the most logical (and widely supported)
  - single-frame BTO

Workflow

- Orders
- FFDM alone – one order (Accession Number)
- DBT alone – one order
- Combined FFDM and DBT – 1 or 2 orders?
- Distinguish ordering from billing
- Can still be one order, one report, two billed codes
- Extra order/billing code for synthetic images?

IHE Workflow

- IHE Scheduled Workflow (SWF)
  - universally adopted (DICOM MWL)
- IHE Mammo Acquisition Workflow (MAWF)
  - exception workflow
  - errors, reject, extra views, repeats (+/- revisit)
- Need workflow-specific DBT IHE updates ?
  - additional ordering codes?
  - additional acquisition codes for images?

Avoid the Alien!