Opportunities and Innovations in Digital Mammography

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Content

• Issues in Breast Cancer Management
• Exposure Control
• Image Processing
• Digital Breast Tomosynthesis (DBT)
• Detector Updates for DBT
• Contrast-Enhanced Digital Mammography
• FFDM - Ultrasound Fusion
Breast Cancer Management Opportunities

“Personalized Medicine”

- Base screening regimens on personal risk profile
- Diagnose disease earlier, avoid unnecessary biopsies
- Base treatment on predicted effectiveness and tolerance
- Quickly assess treatment effectiveness

GE Life Sciences

- Gene analysis and sequencing
- Protein, cellular analysis
- Drug discovery
Breast Cancer Management Opportunities

GE Healthcare, Diagnostic Imaging

- 35% of cancers missed…70% in dense breasts
- ≈ 10% of those screened recalled,
- > 95% of recalls negative…low specificity
- ≈ 80% biopsies are negative
- 1 in 3 breast cancer patients have undiagnosed multi-focal disease
- 1 in 20 those with breast cancer have undiagnosed bi-lateral disease

Source: American Cancer Society, 2004
Breast Cancer Management Solutions

Role of Digital Mammography

- 2000: FFDM enters market via PMA on the basis of “non-inferiority” to film mammography.
- 2005: ACRIN-DMIST confirms overall similarity to film mammography plus benefit for sub-populations.
- Now →: Do procedures with FFDM that are impractical, impossible with film.
AOP
Automatic Optimization of Parameters

• Re-designed for digital imaging
• Optimize Signal Diff. / Noise, not Contrast
• Effectiveness in dense breasts
• Mo / Mo ↓; Rh / Rh ↑
Development of “Digital” AOP

For each thickness and composition, adjust track, filter, kVp, and mAs to find best SDNR at a given AGD.
Optimization Results: SDNR vs AGD

Optimum
SDNR at AGD
for 2, 4, 6, 8 cm

Next step:
Find the best operating point on each curve
Selection of Operating Points

Solution:
Provide set of “trajectories”
- Offer different levels of IQ/Dose compromise
- Respect IQ and Dose constraints
AOP Evolution

Phantom Imaging

Senographe 2000 D
- Mo / Mo, 26 kVp, 125 mAs
- Typical AOP CNT mode
- “film-like” 79%

Seno DS, Essential
- Rh / Rh, 29 kVp, 56 mAs
- Typical AOP STD mode
- “digital”

Optimization drives to selection of Rh/Rh for most patients

Mo/Mo
Mo/Rh
Rh/Rh

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Image Processing

- Optimize display independent of acquisition
- Optimize image resolution, contrast
- Optimize use of display’s dynamic range
- Minimize operator intervention with display
Pre-Processing

- Offset and Gain Correction
- FineView
FineView

- Operates on raw images.
- Compensates for the detector MTF.
- Compensation is dose-dependent.
- May produce unexpected results in quantitative measurements, e.g., noise vs. dose.
Post-Processing

- Auto-contrast
- Tissue Equalization
- Premium View
Tissue Equalization

- Breast tissue visible from chest wall to skin line
- Preservation of anatomical structures

Local contrast

Effect of TE processing

Display dynamic range

Signal Profile

Compressed breast
Tissue Equalization

Original

Tissue Equalization

Enhances visualization of the skin line

Contrast similar to film
• **Automatic** local contrast optimization across entire image
• Breast tissue visible from chest wall to skin line
• Preservation of anatomical structures
• Increased contrast
Premium View – How it Works

Baseline Image → Low Pass → Weighted Low Pass → Weighted High Pass → PV Image

Baseline Image → High Pass → Weighted High Pass
Premium View

Tissue Equalization

Premium View

PV equalizes background and enhances local contrast in high and low exposure regions.

Minimizes need for windowing & leveling.
The following devices are investigational and have not been approved for sale within the United States by the US Food and Drug Administration (FDA). These devices may or may not be commercialized in the future.
Digital Breast Tomosynthesis

Unmet Needs

• 30%-50% Cancers in dense breast tissue missed with 2D mammography
• High inter-observer variability… missed cancers
• >95% screening recalls are negative
• No direct 3D localization

Clinical Value

• Increased clinical accuracy diagnostic confidence
• Less observer variance
• Reduced patient anxiety with fewer recalls
• Direct 3D localization

Promising imaging application for screening and diagnosis of cancer
DBT Reveals Occult ILC

2D FFDM

Tomoynthesis Slice

Images courtesy of Drs. Di Maggio & G Gennaro,
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DBT Image Quality Factors

**FFDM IQ Drivers**
- Radiation Dose
- Beam Quality
- Detector Properties
- 2D Image Processing
- Image Display

**Additional DBT IQ Drivers**
- Aperture Angle
- Number Exposures
- Projection Dose
- Sweep Time
- Pixel Readout
- 3D Display Tools
- 3D Recon Algorithm
DBT Challenges

• DBT Patient dose to be ~ same as 2D mammo.
• Number of projections ~ 10 - 20
  – Dose/projection <~ 1/10 dose for 2D mammo.
  – Need low-noise detector
• Compression time ~ same as 2D mammo.
  – Need fast read-out, low-lag detector
• Image processing time
  – 10X more… from seconds to minutes
• Softcopy workflow and productivity
  – > 10X more images… from 4-6 to 100-200
• Transmission & archival
  – 25X more… from 60MB to 1,500MB
Detector

Prepare for DBT
Detector Operation

Cesium iodide converts x-rays to light, crystal acts as light pipe.

Photodiode converts light to electric charge

Charge at each pixel read out by low-noise electronics and converted to digital data
Detector Updates

- Thinner Graphite Cover
  Decrease x-ray attenuation
  Slight increase in DQE
- Thicker CsI Scintillator
  Increase x-ray conversion
  Increase DQE
- Larger panel size, 24 x 31 cm²
  Coverage for oblique incidence
- Storage capacitor added
  Increase dynamic range
- Revised panel circuitry
  Increase readout rate
  Decrease noise
Senographe Essential DQE

14X drop in detector exposure; only 7% drop in L.F. DQE

Albagli, SPIE 2005
Contrast Enhanced Digital Mammography (CEDM)

• Screening high-risk women
• Staging, determining extent of disease
• Problem solving
• Therapy planning, response monitoring
Two Imaging Methods

Temporal Subtraction

- n exposures, 1 energy, few minutes

Dual-Energy Subtraction

- 2 exposures, 2 energies, ~ same time
2D Temporal Subtraction

**Technique:**
Mo/Cu, 45 kV, 100 mAs

**Period:**
T = 60 s

Images courtesy of Charite

Investigational program. Limited by US federal law to investigational use.

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Dual-Energy Subtraction

Images courtesy of Dr Dromain, Institut Gustave Roussy – Villejuif, France

Dual-energy more reproducible… avoids motion artifacts

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FFDM - Ultrasound Fusion

Unmet Needs

- 30%-50% Cancers in dense breast tissue missed with mammography
- Some cancers provide low X-Ray contrast or differentiation
- Ultrasound technique manual, operator-dependent & time consuming

Clinical Value

- Increased diagnostic confidence & accuracy
- Reduced patient anxiety with fewer recalls
- Improved workflow
**FFDM/US Fusion**

**Mammography**  **Ultrasound**  **FFDM / US Fusion**

- **High resolution**
- **High sensitivity**
- **Microcalcification detection**

**But:**
- **Low specificity for mass lesions**

- **High specificity** (i.e., cysts vs. solid)
- **3D imaging**

**But:**
- **Operator dependent**
- **Can’t visualize microcalcifications**

**Best of both modalities**
- Image registration
- Real-time imaging
- No operator dependence

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Thank You