Combined Pulse Echo Ultrasound, X-Ray Tomosynthetic, Photoacoustic and Speed of Sound Imaging for Potential Breast Cancer Detection

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Disclosures and URL

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www.ultrasound.med.umich.edu/PLC/PLCpresentnRSNA2Notes.pdf

Outline

- Multimodality Breast Imaging Systems
  - X-ray
  - Ultrasound
  - Photoacoustic
- Research systems available
  - Strain/shear wave velocity
  - Full & Lim. Ang. Tomo.
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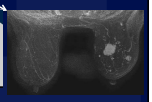
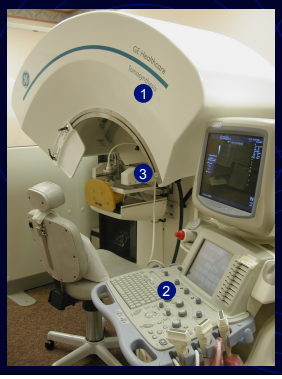
The future of the world, i.e., automated breast US screening - divided into 3 geometries

- Supine for US plus optical imaging
  - Not collocated with dependent or compressed breast
- Dependent breast in air or water
  - US with MRI/x-ray CT & Optical/ Microwave
- Conventional mammographic geometry
  - US with Breast Tomo & Optical/ Photoacoustic



SOS MRI
Karmanos Ca Inst., N Duric

Combined BT-AUS system

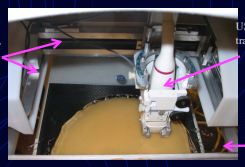


1. Breast Tomosynthesis Unit
2. GE Logiq 9 US Unit
3. Retractable US Scanner, Dual Modality Paddle, then Digital Detector

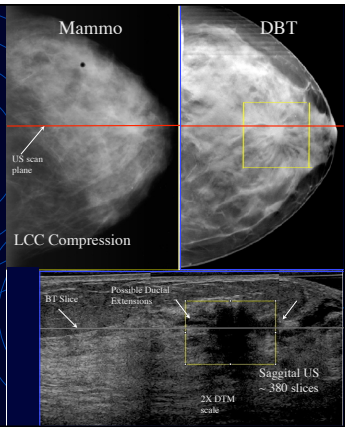
With GE Global Research

Automated US Scanning System

- New mesh paddles allow rapid gel coupling, possibly local compression



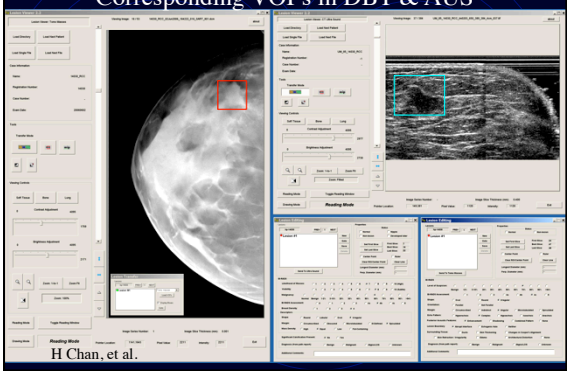
- Translator & transducer are flipped up out of field for BT acquisition



Invasive CA

56 y/o

Colocation Reader Study Display GUI showing Corresponding VOI's in DBT & AUS



H Chan, et al.

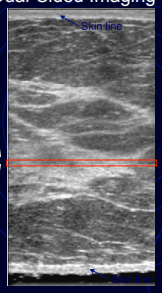
Reader #	DBT	DBT/AUS
1	4.9	7.8
2	4.7	8.0
3	4.5	9.4
4	3.1	7.9
5	2.1	4.5

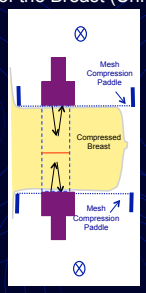
Pilot study of BT + AUS in 51 cases going to Bx[1]; mass visible in BT and in volume covered by AUS

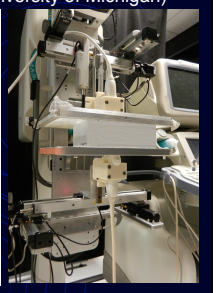
Callback avoidance – subjective question

- *If screening were performed by BT (and US) in this fashion, would tomosynthesis alone allow you to avoid categorizing this case as requiring another diagnostic visit and instead enable you to categorize it as probably benign or suspicious, requiring no additional imagin? (assume no previous comparison mammograms)*
- *1-10 point scale*
- Each Reader, $P<10^{-8}$

Dual-Sided Imaging of the Breast (University of Michigan)

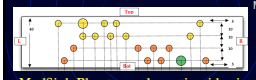






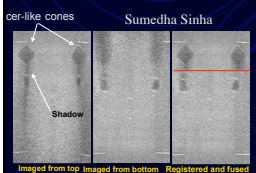
Dual-sided images of compressed breast of a volunteer taken by the University of Michigan using mechanically scanned production M12L
Co-registration was performed by eye (split point shown in red)
NOTE: Image is confidential and proprietary to University of Michigan and GE

Alignment of Scans from Each Side of the Breast, Phantom & Woman's

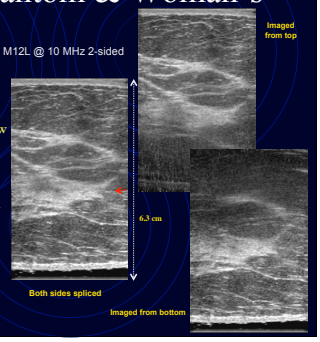


MadSinh Phantom schematic: side view

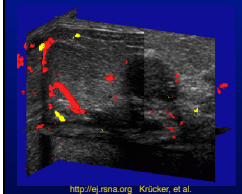
Sumedha Sinha



M12L @ 10 MHz 2-sided

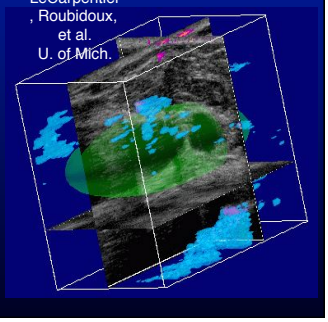


3-D is the way to do Tumor Vascularity & Volume Quantification



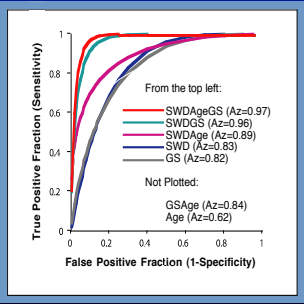
http://ej.rsna.org Krücker, et al.

LeCarpentier, Roubidoux, et al. U. of Mich.



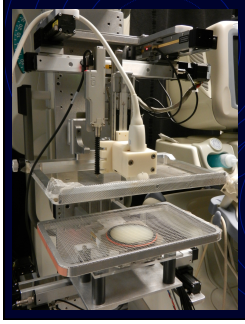
ROC Analysis of Test Cases

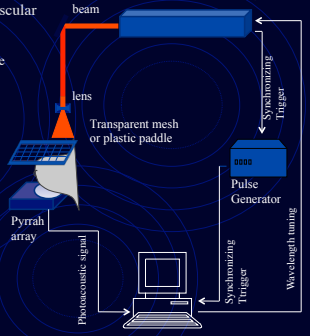
Traditional US geometry



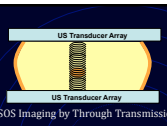
Add a third modality for noncontrast detection and characterization of vascular anomalies of breast cancer

X Wang, Z Xie, Hgsystems & Light Age





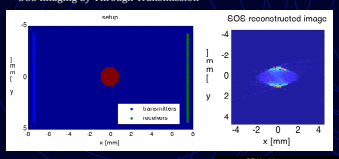
Data Acquisition and Control Unit

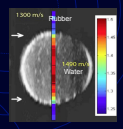


SOS Imaging by Through Transmission

SOS image results for simulated data (below left) and with special-purpose phantom (below right)

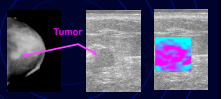
Fong Ming Hooi





Wodnicki R, Thomenius K, Hooi FM, Carson PL, Lin ED, Khuri-Yakub P, Woychik C, "Large Area MEMS Based Ultrasound Device for Cancer Detection," Nuclear Instrum. Methods A, (2010).

- Additions possible to the considerably orthogonal information provided by BT, pulse echo US and S-PAT
- Scatterer size and density (Zagzebski & O'Brien)
- Elasticity, strain or shear wave velocity
- Attenuation
- Acoustic impedance
- Contrast imaging



Elasticity Imaging using a Combined 3D US/Digital X-ray System
Booi, et al., BMES, 2005

Other Ultrasound Modes

Conclusions

- Essentially full, high resolution pulse echo coverage of the breast
- large volume PAT (~ an 8 cm diameter cylinder)
- May have a role as a quick aid to Dx and treatment monitoring but screening is where the need is greatest
- Current 3 modality systems justify initiation of an enhanced screening study of US/BT, with SOS and/or PAT added as method development as exam times allow. Real time CAD should be helpful.
- US to US and BT to BT image registration should improve tracking of low risk abnormalities, cancer detection and nonionizing replacement of some x-rays