Ultrasound and Breast Cancer: Early Detection and Minimally Invasive Treatment

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• Most cancers arise in dense ductal/glandular tissue
• Breast tissue reflectivity, sound speed, attenuation and elasticity properties can be measured using ultrasound
• Most cancers show increased sound speed compared to gland and fat
• We have designed and built a dedicated ultrasound breast scanner that can measure reflectivity, sound speed, and attenuation
• Parametric images can be used to improve visualization of tumors
Ultrasound Thermometry

Sound Speed
- Diagnostic value
  - cancer has elevated sound speed
- Temperature dependent parameter
  - monitor temperature in tissue
- Ultrasound Breast Tomography
  - measure image sound speed

![Graph showing temperature and speed overlay](image)

**Temperature vs. Speed**
- Line: Temp = (0.497) * Speed + (−728)
- Mean Error = −0.09 ± 0.27 °C
- Max Error = 0.64 °C

**Temperature & Speed Overlay**
- r = 0.998

**Sound Speed Image**
- Heat Source

**Sound Speed Evolution**
- Image 1, Time = 0.0 min
- Image 198, Time = 86.0 min

**Water Sound Speed vs. Temperature**
- good parameter in hyperthermia range

**Sound Speed vs. Temperature**
- 1400
- 1425
- 1450
- 1475
- 1500
- 1525
- 1550
- 1575

**Heat Source**

**Temperature & Speed Overlay**
- 20
- 25
- 30
- 35
- 40
- 45
- 50

**Good Parameter in Hyperthermia Range**

**Hyperthermia Range**
- 75 °C
Growing need for minimally invasive treatments and reduced hospitalization

Two approaches for breast tumor ablation:

- **High-intensity-therapeutic-ultrasound (HITU)**
  - Hyperthermia ablation requires accurate temperature quantification to confirm tumor tissue destruction
  - Breast ultrasound tomography offers a non-invasive approach to temperature monitoring
  - Volume data provide targeting data for HITU treatment

- **Robotic Breast Biopsy**
  - Targeting and guidance algorithms localize tumor in volume data and show insertion trajectory
  - Force feedback data / breast stabilization improves small lesion targeting
  - Positions device adjacent to skin surface with insertion under physician direction
  - Lesion targeting accuracy within ±1 mm
Key Concepts and Opportunities for Research:

• Automated *volume breast ultrasound (VBUS)* scanning standardizes imaging and improves tumor localization

• VBUS data provides tumor coordinates to accurately locate tumors

• Image-guided HITU provides a precision method for targeting and treating small tumors without surgery

• VBUS measures tissue temperature distributions based on sound speed

• Robotic Biopsy guided by volume data can accurately sample breast tumors

• Precision robotic biopsy can improve biopsy yield reduce patient trauma