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

Heat Source

Temperature & Speed Overlay

Water Sound Speed vs. Temperature

Temperature vs. Speed

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