
Peer reviewed version

Link to published version (if available): 10.1109/APS.2005.1551515

Link to publication record in Explore Bristol Research

PDF-document

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available: http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/
Experimental Investigation of Real Aperture Synthetically Organised Radar for Breast Cancer Detection

I.J. Craddock, R. Nilavalan, J. Leendertz, A. Preece, and R. Benjamin
Overview

- Breast cancer facts
- The microwave imaging technique used at Bristol.
- Practical measurements using stepped antennas
- Practical measurements using arrayed antennas (not in paper)
- Future work
- Conclusions
Breast Cancer Facts

• Breast cancer is one of the most common cancers in women

• A woman will be diagnosed with breast cancer every 3 minutes in US alone.

• Breast Imaging Techniques
  – X-ray Mammography
    • Relatively high false negative rate: 4%- 34%
    • High false positive rate: 70%
    • Poor contrast resolution
    • Ionising
    • Uncomfortable

  – Ultrasound Methods
    • Small tumours have been detected
    • Poor spatial resolution

  – Contrast Enhanced MRI
    • Too costly for mass screening purposes
Microwave Detection

- Clutter is a major problem.
- Especially skin reflection (also mutuals, tissue inhomogeneity, chest wall).
- A radar technique investigated in the field of Landmine Detection at Bristol gives good clutter rejection by combining all possible TX/RX pairs in an antenna array.
Microwave Imaging

• Real Aperture Synthetically Organised Radar
  – Number of paths is $N(N-1)/2$ (very large)

\[
V = \int_{0}^{r} \left( \sum_{i=1}^{N} c_i U_i(t - t_i) \right)^2 dt
\]
16 Antenna Elements (-10 dB feed-antenna match from 4 to 9 GHz).

Yielding 120 paths.

The antenna elements are excited in turn using a Gaussian-modulated two-cycle pulse at 6.5 GHz and all non-excited elements record the received signals.

Homogenous breast tissue
- Tumour $\varepsilon_r = 50 + j1.02$
- Skin $\varepsilon_r = 40 + j5.86$
Phase 1 Practical Set-Up

• Entire array simulated using mechanically driven pair of antennas.

![Graph showing Emulsion Dielectric Properties]

- **Permittivity**
- **Attenuation (dB/cm)**

Freq. (GHz) vs. Permittivity and Attenuation
Phase 1 Raw Time-Domain Data

Skin Reflections and Tumour Echo

Mutual Coupling

Signal Strength

Time / (ns)
Phase 1 Results

- Skin effect mitigated using a similar path technique.

- 6mm tumour (position x = 46mm, y = 69mm, z = -45mm).
Phase 2 Practical Setup

- Fully-populated array replaces mechanically-scanned antennas
- Scan time of 2 minutes
Phase 2 Practical Setup – phantom tank and array
Phase 2 Practical Setup – microwave switches
Phase 2: Practical Setup - switch drivers
Phase 2 Practical Setup
Phase 2 Experimental Results

- 4 mm tumour
- 120 Paths for focusing
- Full background subtraction to reduce skin clutter
Phase 2 Experimental Results

- 6 mm tumour
- 20mm from skin
- Offset method used to reduce skin clutter
Phase 2 Experimental Results

- 6 mm Tumour
- 15mm from Skin
- Similar paths used to reduce skin clutter

- Similar path measurements not sufficiently similar.
Conclusions

- Breast cancer detection using microwaves would be a very attractive, freely repeatable, and low-cost alternative, or adjunct, to Mammography.
- Detailed, realistic, FDTD models have been invaluable in designing antenna elements and validating the focussing and clutter-rejection techniques.
- Skin clutter rejection techniques arise from the identification of similar paths with the array.
- Improved experimental accuracy is now a priority (e.g. more repeatable switch performance).
- A curved array and phantom is under construction.