ELECTRICAL AND COMPUTER ENGINEERING
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Microwave Radar for Breast Imaging

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Radar avec micro-ondes pour l'imagerie du sein

Motivation

- Early detection is essential. 5-year survival rate after metastasis: only 23% [1].
- Our system uses electrical contrast of tumor vs. healthy tissue at microwave frequencies.
- Microwave system potential: non-ionizing, pain- and compression-free, cost-effective cancer detection [2].

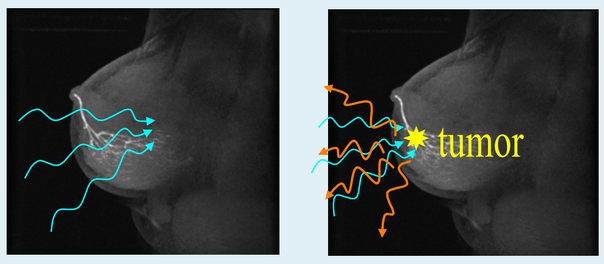
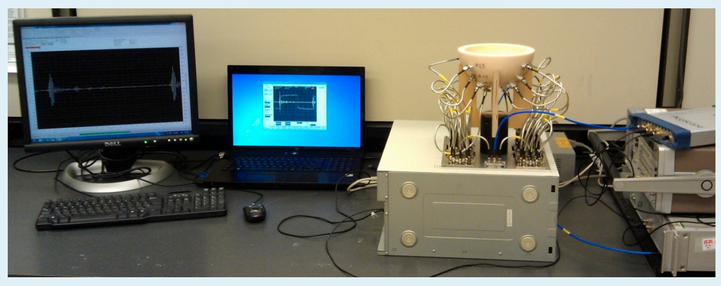
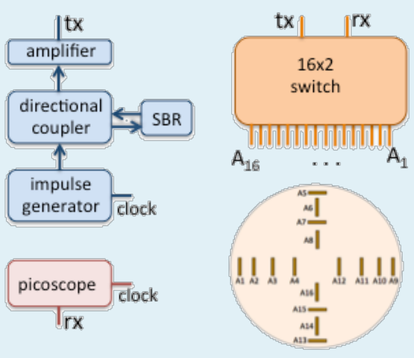


Fig. 1. Depiction of the microwave breast imaging concept [3].

Measurement Set-up

- 16-element antenna array located on exterior of radome
- Breast is placed inside radome, with a gel filling gaps between the skin and radome walls
- A pulse is transmitted from each antenna in turn, and the signal scattered off the breast is received by each other antenna and recorded in the time-domain





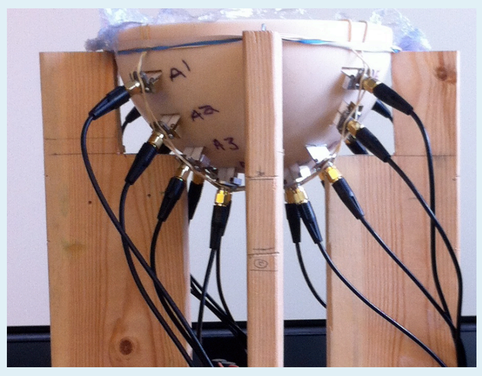


Fig. 2. Measurement set-up (top), schematic (bottom left), radome and antenna array close-up (bottom right).

Testing with Breast Phantoms

Tissue Phantoms

- Fat, skin, gland, and tumor-mimicking tissue phantoms
- Made from common chemicals [4]
- Dielectric properties of each tissue phantom match those of real breast tissues [5]

Complete Phantoms

- Electrically and anatomically realistic models
- 1-cm radius tumors embedded at two distinct locations

Fig. 3. Photographs of a realistically-shaped breast phantom.

Sample Results

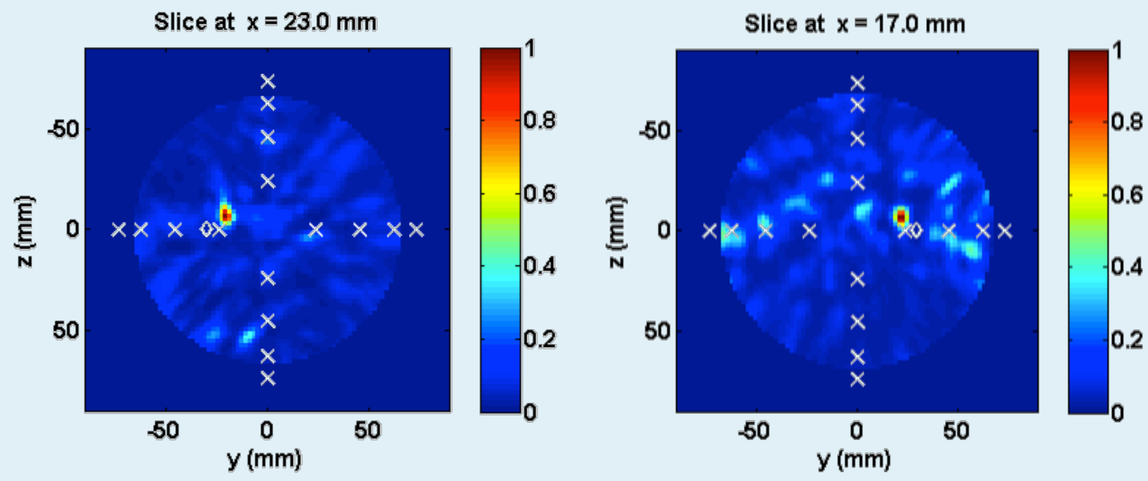


Fig. 4. Successfully reconstructed images of breast phantoms with tumor in Position 1 (left), and Position 2 (right).

	Position 1	Position 2
SCR (dB)	8.2	6.8
Error (mm)	14	11

Table I. Image parameters for tumors in positions A and B: Signal-to-clutter ratio (SCR) and tumor localization error [6].

First Prototype: Clinical Testing

Clinical Trials

- Patient-ready interface [7]
- Goal: to test system feasibility on real breast tissues
- Approved by McGill University

Fig. 5. Photograph of the clinical implementation (above) and the recruitment poster (right).

Future Work

- Assess system feasibility through clinical trials
- Use trial feedback to optimize the system performance

References

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[2] E.C. Fear, P.M. Meaney and M.A. Stuchly, "'Microwaves for breast cancer detection?'" *IEEE Potentials*, pp. 12-18, February/March 2003.
[3] H. Kanj, "Resistively-Loaded Antenna Designs for Ultra-Wideband Confocal Microwave Imaging of Breast Cancer," Ph. D. Thesis, Dept. Elec. and Comp. Eng., McGill Univ., Montreal, Canada, 2007.
[4] M. Lazebnik et al., "A large-scale study of the ultrawideband microwave dielectric properties of normal, benign and malignant breast tissues obtained from cancer surgeries," *Phys. Med. Biol.,* Vol. 52, pp. 6093-6115, 2007.
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[6] E. Porter, E. Kirshin, A. Santorelli, M. Coates, and M. Popović, "Time- domain multistatic radar system for microwave breast screening," *IEEE Antennas Wireless Propag. Lett.*, vol. 12, pp. 229-232, 2013.
[7] E. Porter, E. Kirshin, A. Santorelli, and M. Popović, "A clinical prototype for microwave breast imaging using time-domain measurements," in *Proc. Antennas and Propagation (EuCAP), 2013 7th European Conference on*, pp. 830-832, Gothenburg, Sweden, Apr. 8-12, 2013.