Development and 3D Printing of MRI-Derived Breast Phantoms for Microwave Imaging

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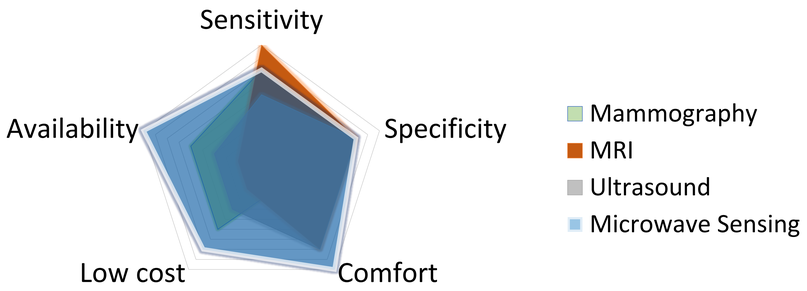
Introduction

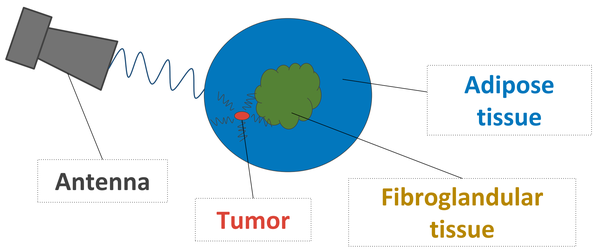
It is estimated that 1 in 8 Canadian women will get breast cancer in their lifetime and 1 in 33 will die from breast cancer [1]

Characteristics of breast imaging technologies



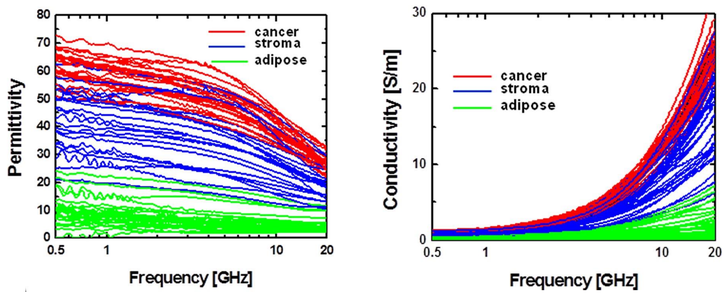
Microwave Imaging

Microwave imaging uses non-ionizing radiation and compared to other imaging modalities is low cost and does not require pre-trained operator.



Representation of microwave imaging

The difference in the dielectric properties (permittivity and conductivity) of healthy and malignant tissues forms the basis of contrast in breast microwave imaging



Dielectric properties of the breast tissues [2]

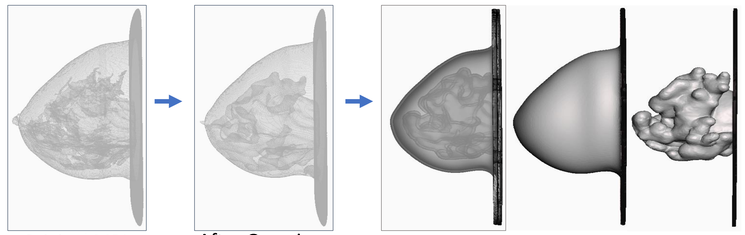
Breast Phantoms

- Previous breast phantoms mimicked the dielectric properties of the breast tissue but did not accurately reflect breast morphology.
- 3D printed shells derived from MRI images are able to represent the breast morphology and can be filled with surrogate liquids that mimic the dielectric properties of tissue, making them excellent breast phantoms.

Methods

Design of MRI-Derived Phantoms

Phantoms designed from the University of Wisconsin-Madison Breast Phantom Repository [3][4]

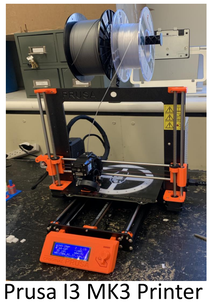


Original MRI Data → After Gaussian Blurs → 3D Printable Model

3D Printing Phantoms

Phantoms were printed at the University of Manitoba

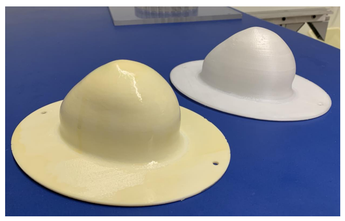
Phantom Printed at the University of Manitoba



Prusa I3 MK3 Printer

Material Comparison

- Old phantoms printed in polycarbonate (PC) [3]
- New phantoms printed in polycarbonate co-polyester (PC CPE)
- Both were scanned and side by side and images were compared

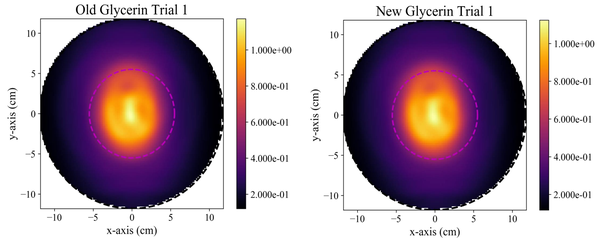


Results

18 MRI-Derived Phantoms Designed and Printed

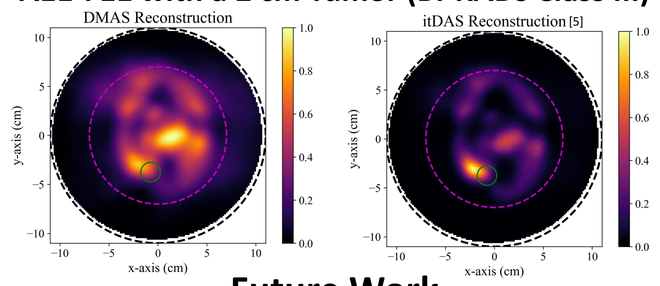
18 Phantoms were printed (9 adipose shells and 9 fibro-glandular shells) giving 66 unique shell to shell combinations. 1257 scans along with the 3D printable .stl files will be open-access and available to the research community.

PC and PC CPE were found to be different



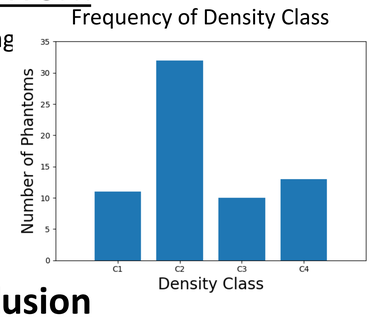
- The intensity in the reconstructed image indicates that the PC CPE shell has a stronger response than the PC shell
- PC CPE was used as the printing material

Image Reconstruction of New Phantom Combination A11-F11 with a 2 cm Tumor (BI-RADs Class III)



Future Work

- Design additional phantoms using an alternative source of breast images such as the cancer imaging archive.
- Shells should be designed to obtain a more uniform distribution of the phantom BI-RADS density classes



Conclusion

- 10 new breast phantoms have been designed, increasing the unique shell combination from 13 to 66
- PC CPE has been selected as new print material
- Printing of the phantoms is being done at the University of Manitoba in the Department of Physics and Astronomy

References and Acknowledgements

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