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A Multi-modal Imaging System for Early Breast Cancer Detection Aimed at Minimizing the Risk of False-positives

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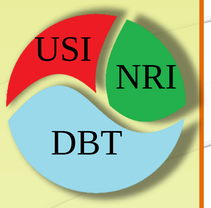
Abstract

Microwave Near-field Radar Imaging (NRI) has the capacity to increase the contrast between malignant and healthy fibrous tissues in breast when compared to X-ray-based imaging systems.

We have developed an NRI mechatronic system that is compatible with Digital Breast Tomosynthesis, a 3D X-ray machine at Massachusetts General Hospital (MGH).

Our system is equipped with a pair of miniature Antipodal Vivaldi Antennas (AVAs) that operate in ethanol and were designed and fabricated in the SICA lab. We are also adding an ultrasound probe to our mechatronic system. The preliminary imaging and Specific Absorption Rate results are presented here



Background

Challenges:

- On average, every **13 minutes**, one woman die due to Breast Cancer in the US. [1]
- The probability of a false-positive conventional mammogram has been estimated be between **9 to 16 percent** [2].
- False-positive results can lead to **biopsies**, **short-term anxiety**, bring about **additional costs**, and have an impact on **patients' tendency to return** for future mammograms [3].

Multimodality Idea:

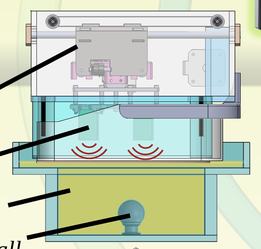
- **DBT**, with its **3D scanning and reconstruction algorithm**, can outperform the conventional mammography by providing a volumetric map of breast tissues [5].

- **Microwave** breast imaging, compared to X-ray imaging, offers **more contrast** between tumor and fibro-glandular tissue [4]

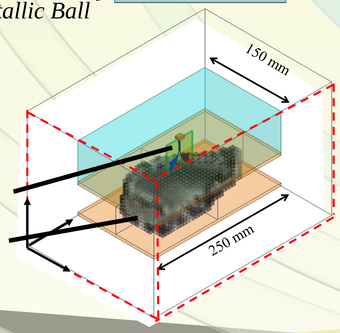
- **Automated breast ultrasound** will be used as the third modality in the system, enabling one to measure density and other properties of the breast [6].

Methods

Experiment: Imaging a bearing ball immersed in sunflower oil, as a simulant of human fatty tissue.



SAR Simulation: Segmenting a breast 3D image taken from DBT into $6 \times 6 \times 6\ cm^3$ voxels and computing the average SAR for 1 gram samples.



Results

SAR Results

The Specific Absorption Rate (SAR) is a measure of the amount of energy absorbed by biological tissue when exposed to an electromagnetic radiation. We used HFSS, a commercial software, to study SAR for 1g samples from a realistic breast model. SAR value is of importance for human subject experiments.

$$Max(SAR)_{range} = 9.3 \times 10^{-4} [\frac{W}{Kg}]$$

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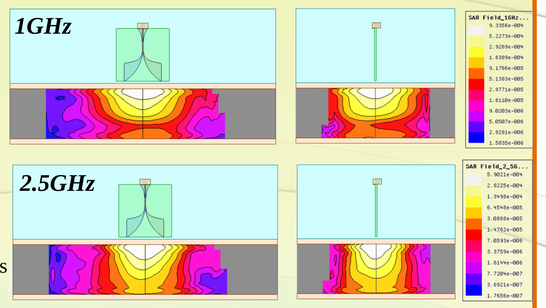
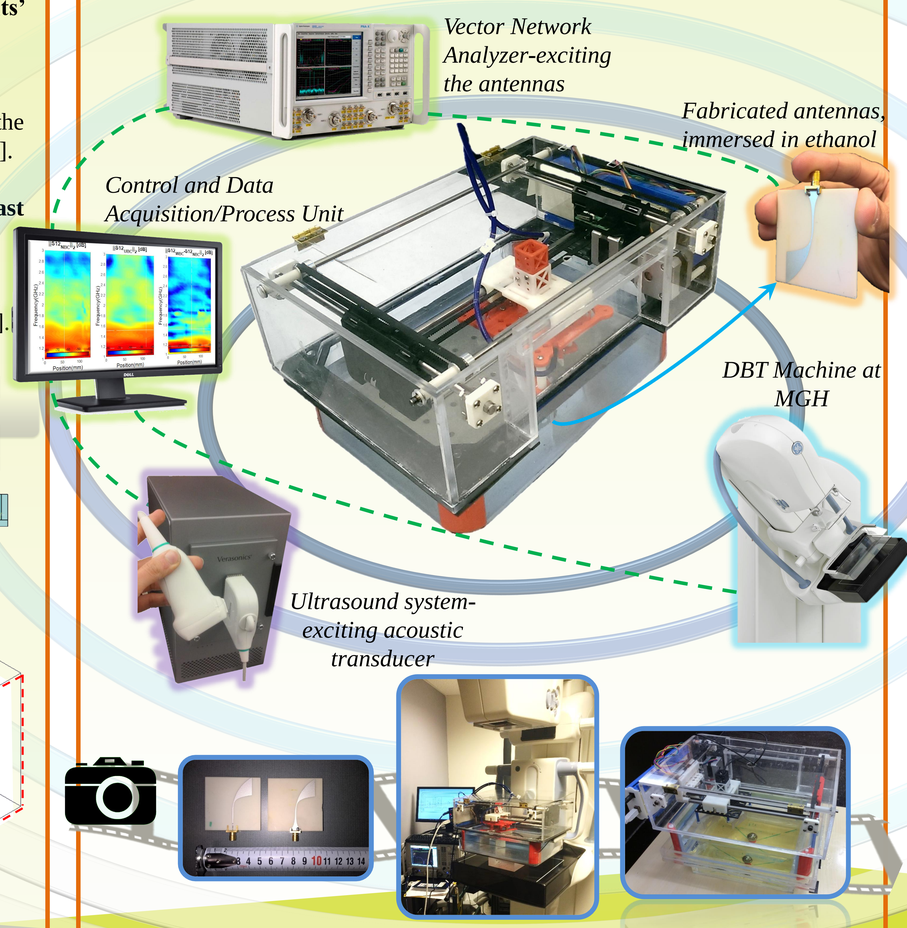
$1.6[W/Kg]^*$

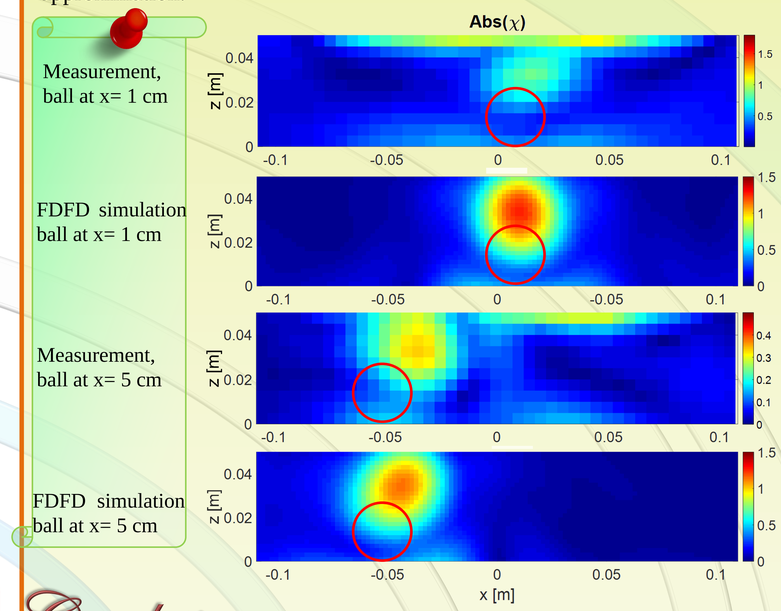
*Federal Communications Commission (FCC) standard.





Imaging Results

We recorded 400 measurements, composed of 16 frequencies in 1-2.5 GHz range and 25 locations with and without the metallic ball in the oil container. Then, we used this data set to compute the vector y in $y = Ax + n$, in which A is the sensing matrix, x is the unknown vector and n is the noise. The Green's function was calculated utilizing a set of 25 HFSS simulations and was employed for the formulation of A matrix according to Born approximation.



Conclusion

We built a Near-field Radar microwave imaging system that can operate compatibly with DBT machine. The results demonstrate that the system (1) can image an object of interest in a homogenous medium, (2) and meets the FCC criterion on SAR values concerning tissue heating.

References

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