Flexible RF Surface Coils for Enhanced Breast Imaging

Melanie Florez[1], Sydney Hankel[1], Alina Jelinski[1], Aleesha Rhodes[1]
Dr. SungMin Sohn, PhD[1]
School of Biological and Health Systems Engineering, Arizona State University

Introduction

1 in 8 women in the United States have a chance of developing breast cancer [1]. Acquiring imaging is the first step in a patients journey and 9.7% of women undergoing breast MRI encounter false positives due to artifacts / misinterpretations which can be attributed to low Signal-to-Noise Ratio (SNR). Additionally, 64% of women experience pain or discomfort during scans [2].

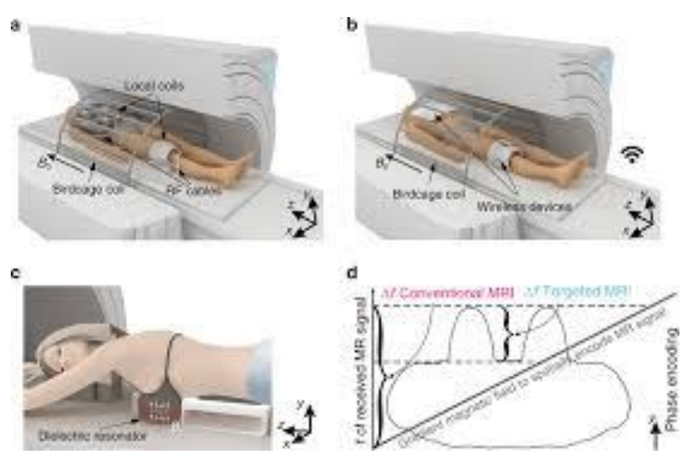

Figure 1: Traditional MRI rigid breast coil, patient in prone position. [3]

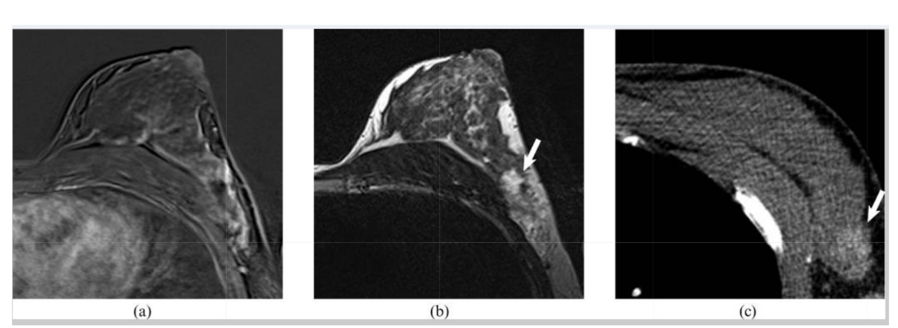

Figure 2: Clinically palpable breast cancer [4]
(a) does not show any mass
(b) T2 weighted image shows palpable mass, but has irregular margins
(c) CT scan shows mass clearly

Our mission is to provide quality imaging and comfort for every patient.

Technical Models

Resonant Frequency:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Inverse Square Law:

$$I \propto \frac{1}{r^2}$$

Virtual Prototyping/ Simulations

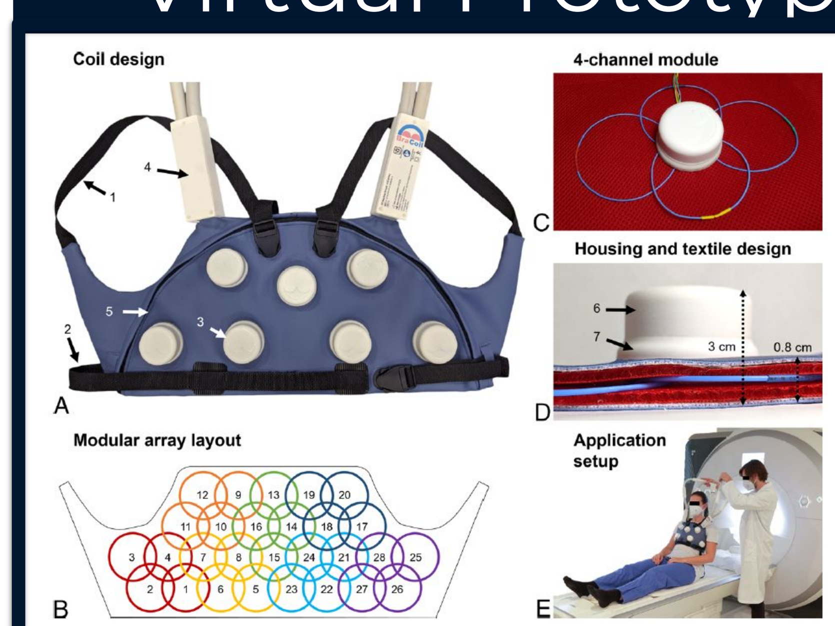

Figure 3:
Our device is based off of "BraCoil" [5] using a smaller coaxial cable diameter, providing a higher sensitivity to receive signals.

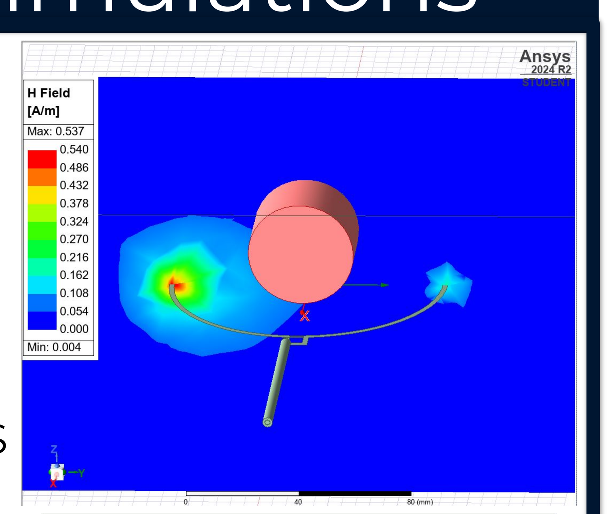

Figure 4: Breast Phantom and coil B field in Ansys-HFSS

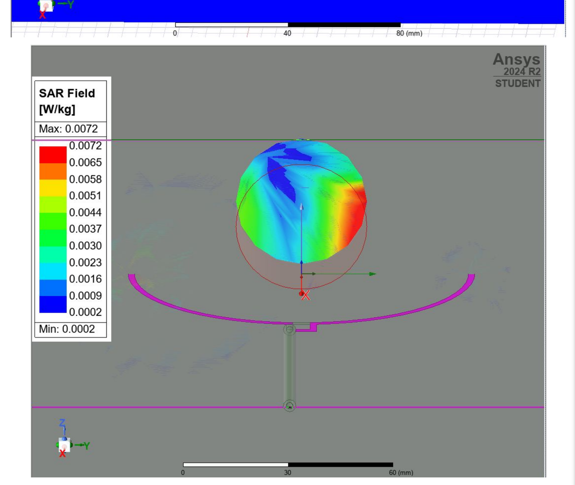

Figure 5: Specific Absorption Rate field

Prototyping

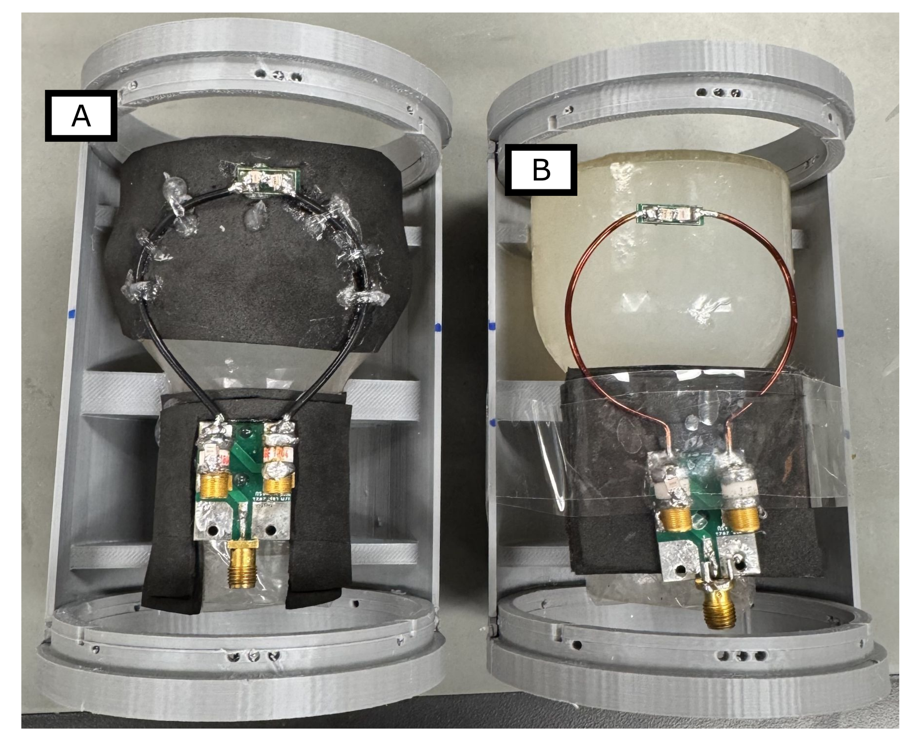

Figure 6: Prototype of the imaging coils. The left slide displays the flexible coil (A), designed for adaptability and improved patient comfort, while the right side shows the rigid coil (B), representing traditional, structured design.

The flexible coil contains two capacitors with values of 2.2pF and 1.2pF, resulting in a total capacitance of 0.776pF. It also includes a 10pF capacitor within the L-matching network and yields a resonance frequency of 395MHz. The rigid coil contains two capacitors with values of 3.0pF and 2.4pF, resulting in a total capacitance of 1.33pF and yields a resonance frequency of 390MHz.

Results

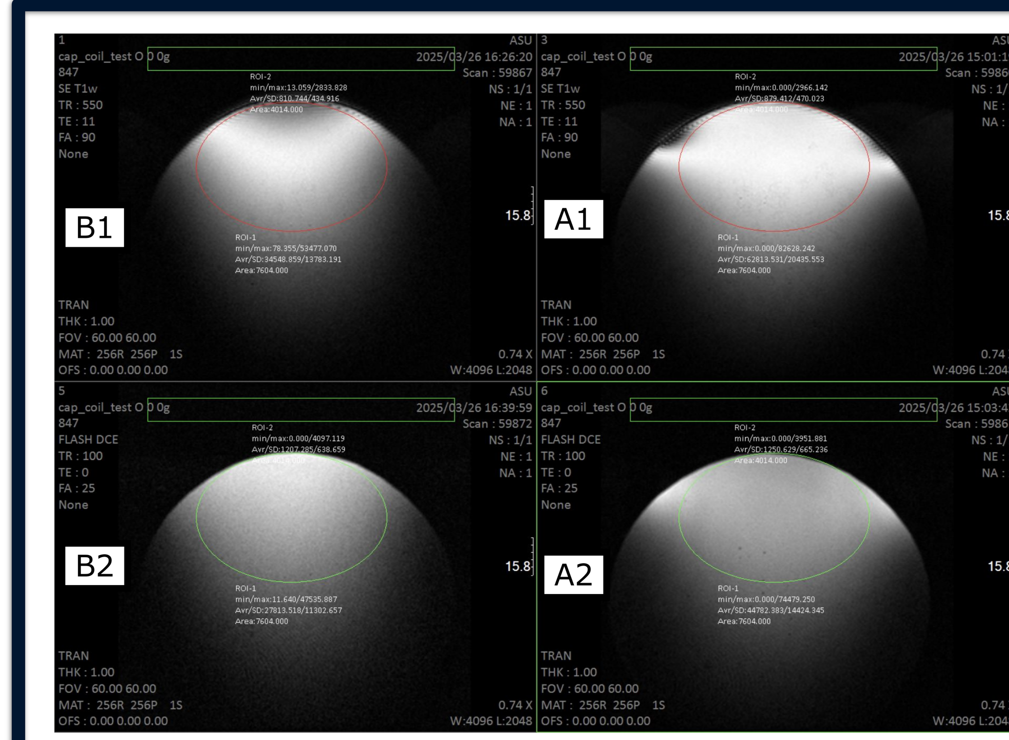

Figure 7: Imaging results of an agar phantom using a flexible coil (*A1, A2*) and a rigid coil (*B1, B2*) with a 1 mm slice thickness. For the flexible coil, *A1* presents a spin echo sequence (**18.45% SNR increase**), *A2* shows a gradient echo sequence. Similarly, for the rigid coil, *B1* depicts a spin echo sequence, and *B2* displays a gradient echo sequence (**20.74% SNR increase**).

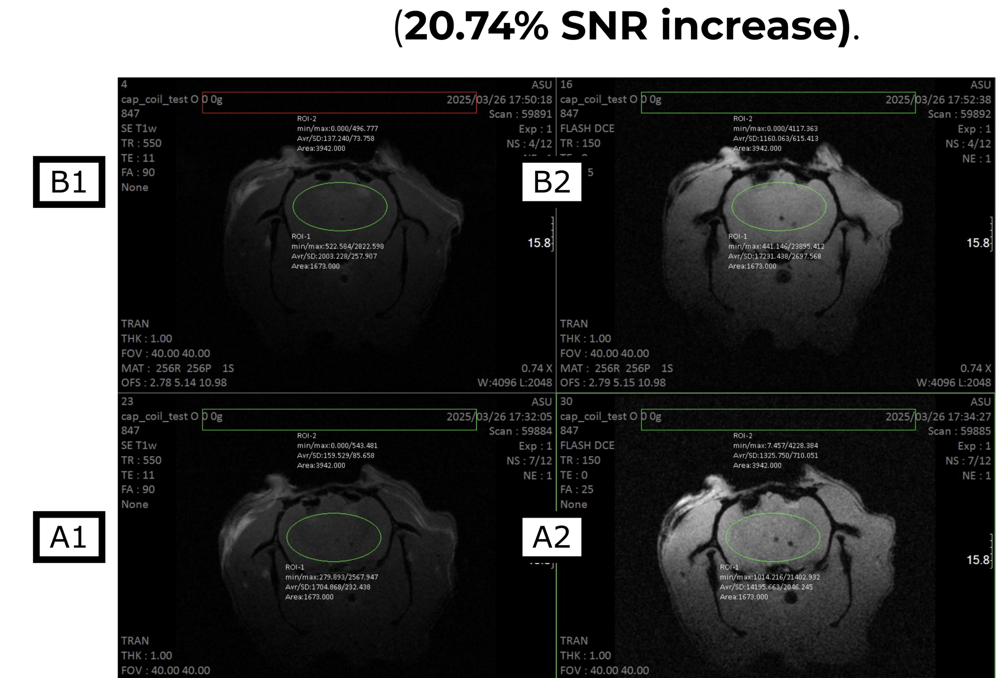

Figure 8: Imaging results of a rat brain using a flexible coil *(A1, A2)* and a rigid coil *(B1, B2)* at a 1 mm slice thickness. For the flexible coil, *A1* presents a spin echo sequence, while *A2* shows a gradient echo sequence. Similarly, for the rigid coil, *B1* depicts a spin echo sequence, and *B2* displays a gradient echo sequence.

Analysis

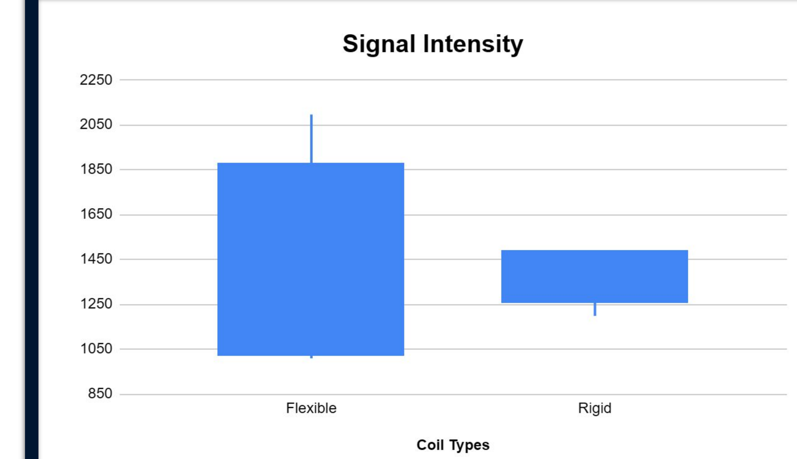

Figure 9: Flexible coil demonstrated a wider and stronger signal response compared to Rigid coil, therefore suggesting greater sensitivity across tissue regions due to closer anatomical conformity
Higher Signal Intensity = Better Signal

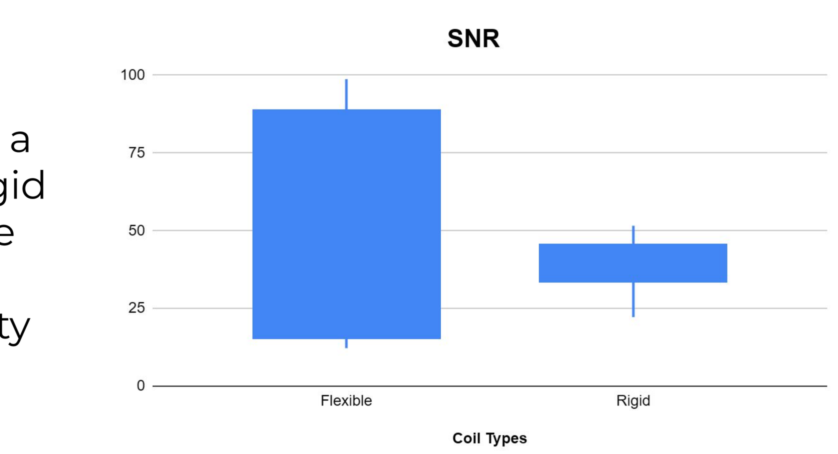

Figure 10: Flexible coil demonstrated a significantly higher peak than the Rigid coil with a broader interquartile range which indicates better imaging performance and overall image quality
Higher SNR = Clearer Imaging

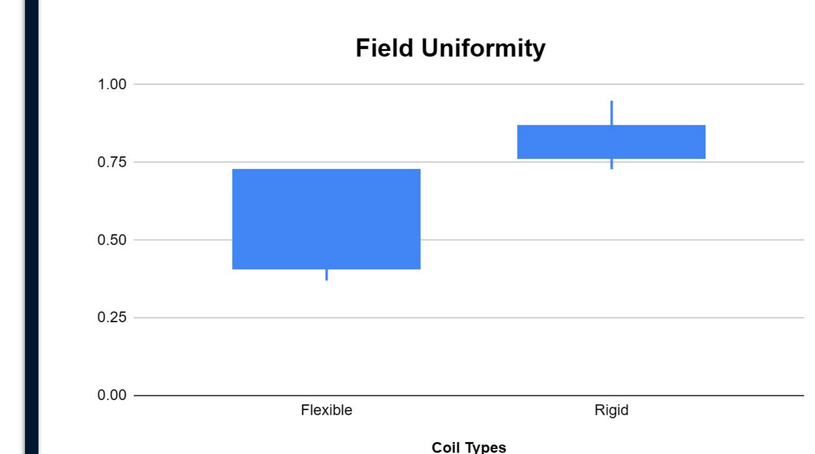

Figure 11: Flexible coil presented more uniformity and variability compared to Rigid coil therefore demonstrating the ability to adapt to body contours and maintain homogeneous field distribution
Lower Uniformity = More Even Signal Distribution

Future Steps

- Testing multiple iterations of the flexible coil
- Exploring alternative attachment methods
- Further optimizing the circuit design
- Combining several coils for maximum surface coverage
- Implementation of automatic matching and tuning

Acknowledgements

Special thanks to our faculty mentor Dr. SuhnMin Sohn, and to current PhD student Chavalchart Herabut, the Arizona State University's Biomedical Engineering Department, Capstone advisors, and industry mentors for their support and guidance in developing a more comfortable imaging experience for breast cancer diagnostics.

References

Project TImeline-Gantt Chart	House of Quality	Technical Modeling	References