SONAR: Breast Lesion Localization Solution

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***Our Mission**: Develop an advanced breast localization solution that offers surgeons precise and reliable tumor identification, ultimately improving patient outcomes by reducing the need for repeat procedures and lowering the financial burden on patients.*

Clinical Need

Breast lesion localization is used in surgeries to pinpoint non-palpable breast tumors for removal. Current wire-guided methods have drawbacks, including patient discomfort, logistical issues, and safety concerns.

Design Input

Customer Needs: Accuracy, comfort, safety, efficiency, and usability
Metrics: frequency of additional surgeries, localization rate, procedure length, and ease of use.
Primary Users: Becton-Dickinson (Manufacturer) and clinicians
Economics: 2023 market valued at $1.13-$1.12B USD, CAGR 7.8% - 11.7% from 2024-2033

Product Concept

Solution: handheld probe, similar to a metal detector that will pick up on the signal of magnetic seeds implanted on lesions, allowing clinicians to directly locate magnetic markers.
Advancements in the technology:

- Adjustable field strength for flexibility at various depths
- Non-invasive and patient friendly
- Compatible with minimally invasive surgical practices

Final Technical Models

1. Solenoid for a Magnetic Field

$$B_{solenoid} = \mu_0 \frac{NI}{l}$$

2. Force Between Magnetic Seed and Handheld Detector

$$F = \frac{\mu_0 \cdot m_1 \cdot m_2}{4\pi r^2}$$

Design for Manufacturing & Final Specifications

SONAR Device

Specification	Target Value
Seed Radius	0.5 mm
Seed Length	5 mm
Probe Tip Radius	1.5 cm
LCD Screen	72mm x 27 mm

3D Modeling

Specification	Target Value
Tip Width	14.73 mm
Cone Diameter	172.2 mm
Tip to Funnel Top	94.9 mm
Rim Width	0.89 mm

Circuitry

Specification	Target Value
Distance Accuracy	±2 mm
Detection Range	0-15 mm
Update Frequency	10 Hz
Feedback Mechanism	RGB LED (Green: <5 mm, Yellow: 5-10 mm, Red: >10mm)

Item	Price
Arduino Uno	$27.60/unit
Hall Effect Sensor	$4.26/unit
LCD Screen Display	$14.39/unit
LED Diodes	$8.99/unit
Total Cost **price of materials**	**$55.24**

Verification Results

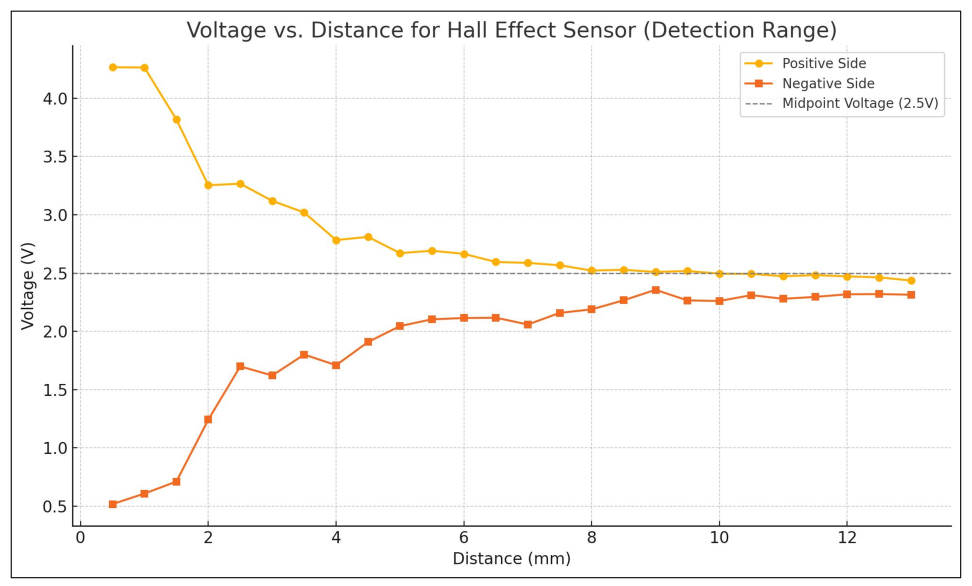
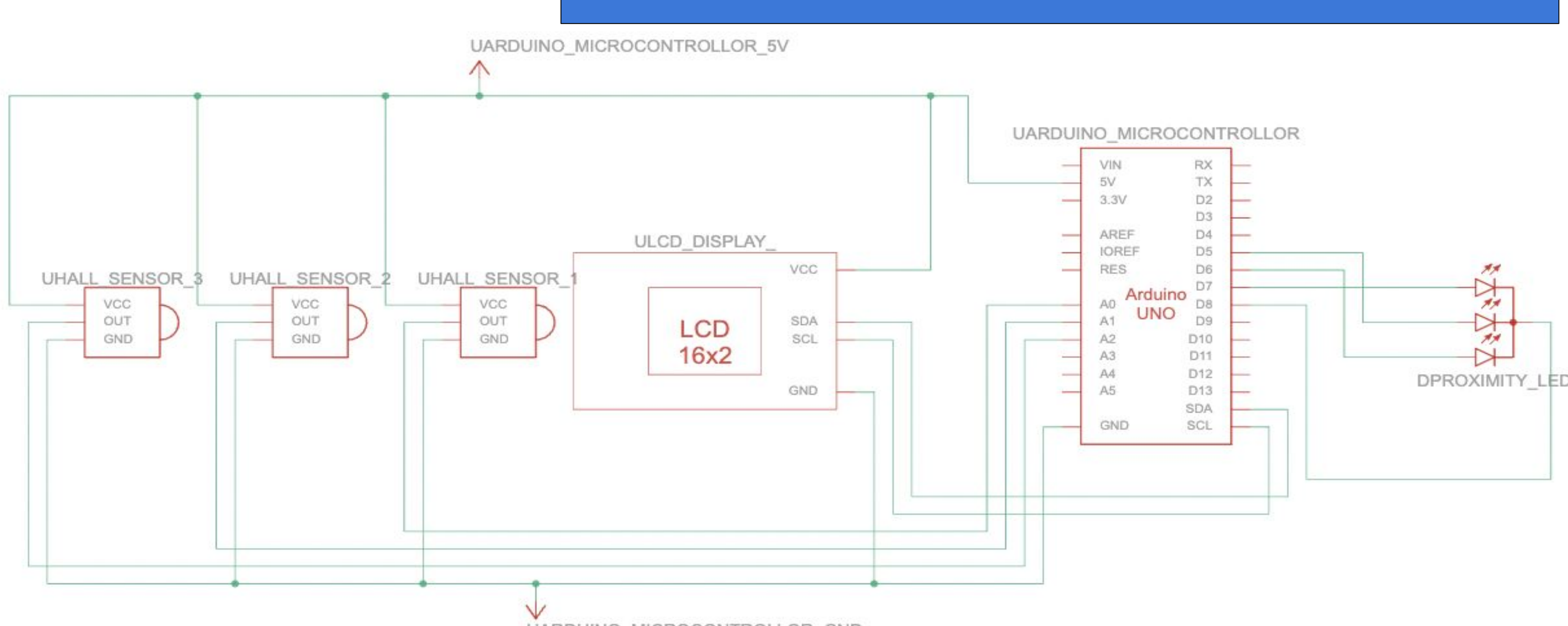
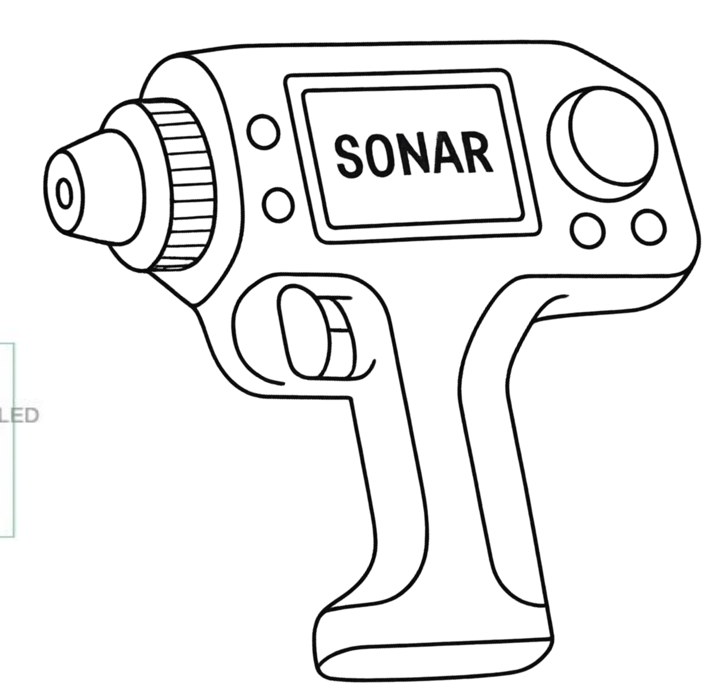


Figure 1. Plot of Hall effect sensor voltage versus distance from the neodymium magnet, demonstrating a consistent inverse relationship between magnetic field strength and distance. The curve validates the sensor's responsiveness and supports accurate distance estimation within the prototype's functional range.

Final Design Concept





Our final prototype demonstrates proof of concept for a magnetic seed localization device, integrating three angled Hall effect sensors to enable 3D spatial detection within a breast tissue model. Powered by an Arduino Uno R4 Minima, the system outputs real-time feedback through an RGB LED and LCD screen, displaying distance-based signals and sensor voltages with a maximum detection range up to 30 mm.

Design & Performance

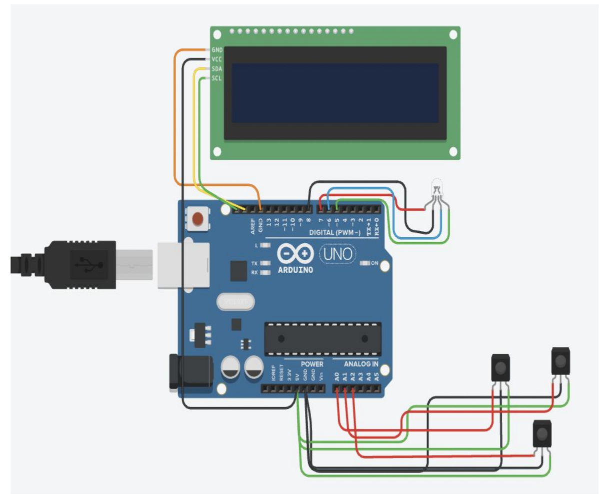


Figure 2. Circuit schematic of handheld detector system using Arduino Uno, LCD screen, and Hall effect sensors.

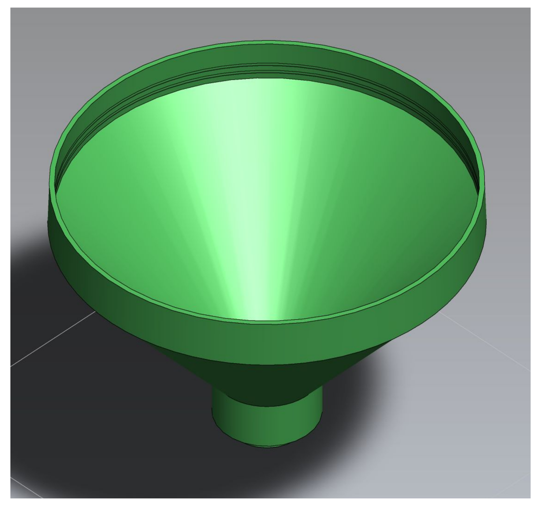


Figure 3. Cross-sectional 3D CAD model of the breast phantom mold, featuring a conical cavity for anatomical simulation.

Breast Phantom Modeling

Specification	Target Value	Price
Structural Stability	≥ 8 oz. of boiling water, ≤ 8 oz. of unflavored gelatin powder	$14.99/unit of gelatin powder
Anatomical Properties	≥ 3 olives	$7.37/unit
Signal Detection	≥ 3 magnets	$10.99/unit

Future Directions

- **Clinical-grade prototype with sterile housing**
- **Bench-top Testing**
- **Initiate FDA pathway planning (510k)**

Acknowledgements

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References

Youtube Video