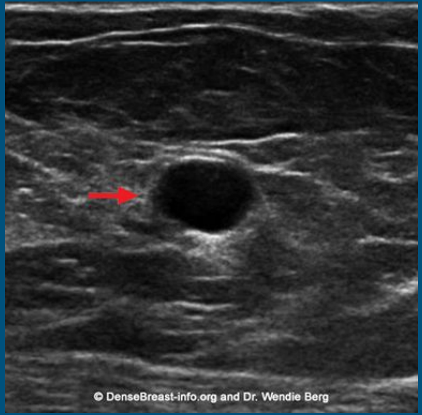
Deep Learning–Based Ultrasound Lesion Segmentation & Subtype Classification

Presenter: Varsha V-ML Undergraduate Researcher
Affiliation: Lampe Joint Department of Biomedical Engineering
Funding: NSF Graduate Research Fellowship

Introduction- Breast Cancer Ultrasound

- Mammography Partner: Ultrasound complements X-rays, especially in dense breasts where tumors hide.
- Safe & Accessible: No ionizing radiation, lower cost, widely available in clinics and mobile units.
- Real-Time Guidance: Instant feedback for lesion detection and biopsy needle placement.



Significance

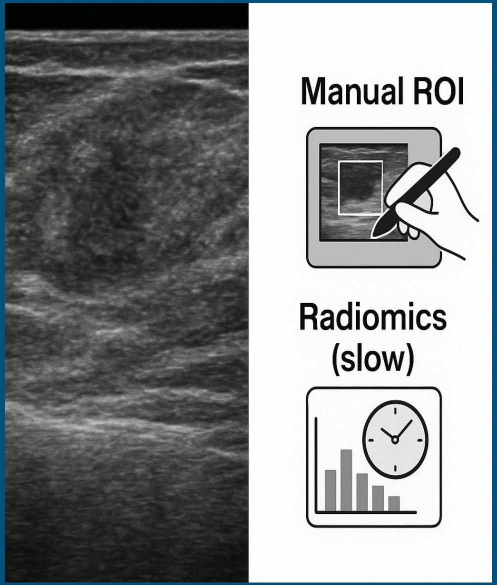
Remaining Gaps

1. Manual Steps: Someone still has to outline the tumor
2. Speed vs. Detail with current computer tools: Fast models miss small features; detailed ones lag behind
3. No One-Click Tool: No single, real-time, scanner-diagnostic system

Past Attempts with AI

- Radiomics + Statistics (Ferre et al. 2023): Good AUC (~0.82), but needed radiologists to draw masks by hand
- Vision Transformers (Pacal 2022): High accuracy (~89 %), yet processed whole frames slowly—no live guidance
- LightGBM Models (Michael 2022): Very fast and accurate, but relied on pre-computed features and separate steps

B-mode Breast US of dense tissue



Aim 1 – Automated Attention-Enhanced Segmentation

Goal

- AI draws tumor outlines fully automatically—no more hand-tracing.

Model

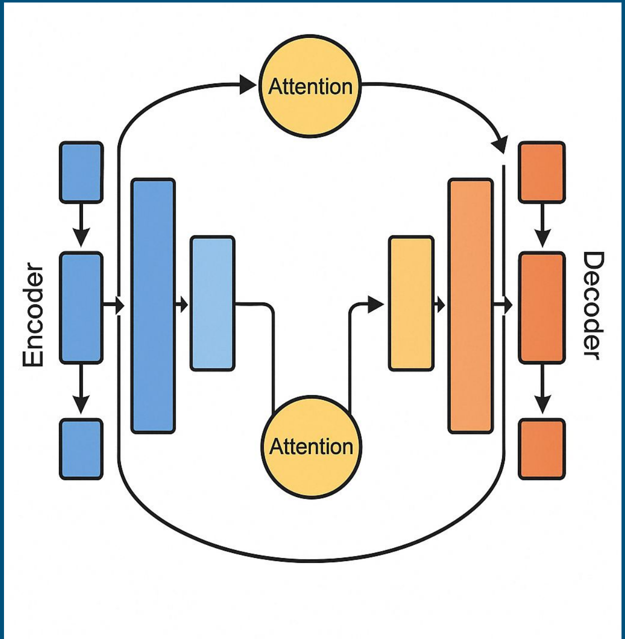
- Residual U-Net (U-shaped encoder–decoder)
- Spatial & channel attention modules highlight the tumor region

Training

- 100 expert-annotated B-mode ultrasound volumes

Loss Function

- Dice loss: rewards overlap between AI mask and expert mask
- Focal loss: emphasizes hard-to-classify pixels



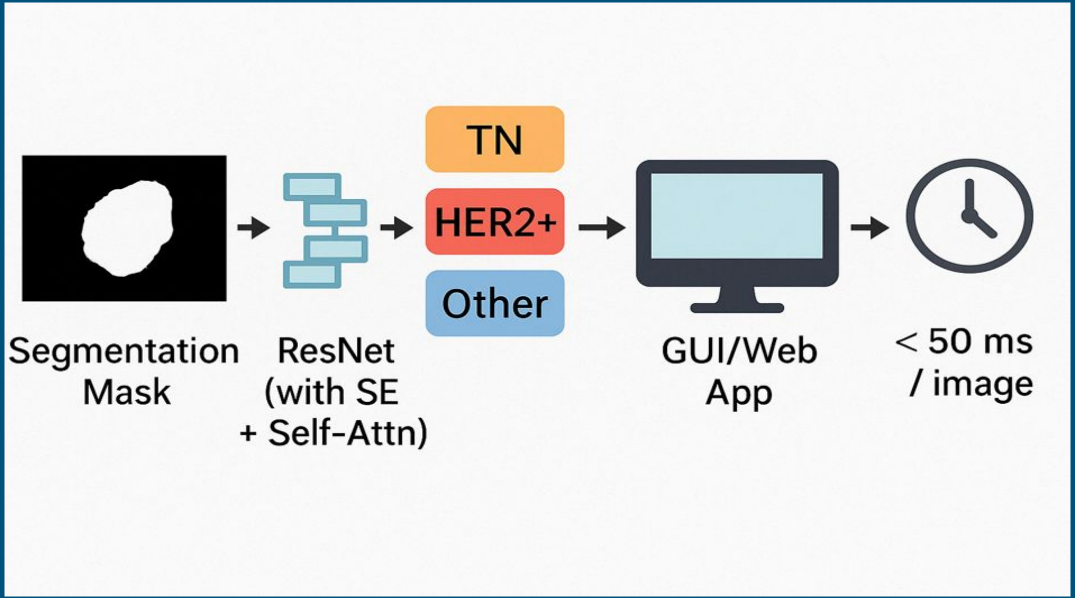
Evaluation (50 Held-Out Scans)

- Overlap vs. 2 Radiologists
  - *Dice coefficient* (0 = no overlap → 1 = perfect match)
  - *Intersection over Union* (shared area ÷ total area)

- **Benchmark: AI's agreement matches or exceeds radiologist–radiologist consistency ($p < 0.05$**

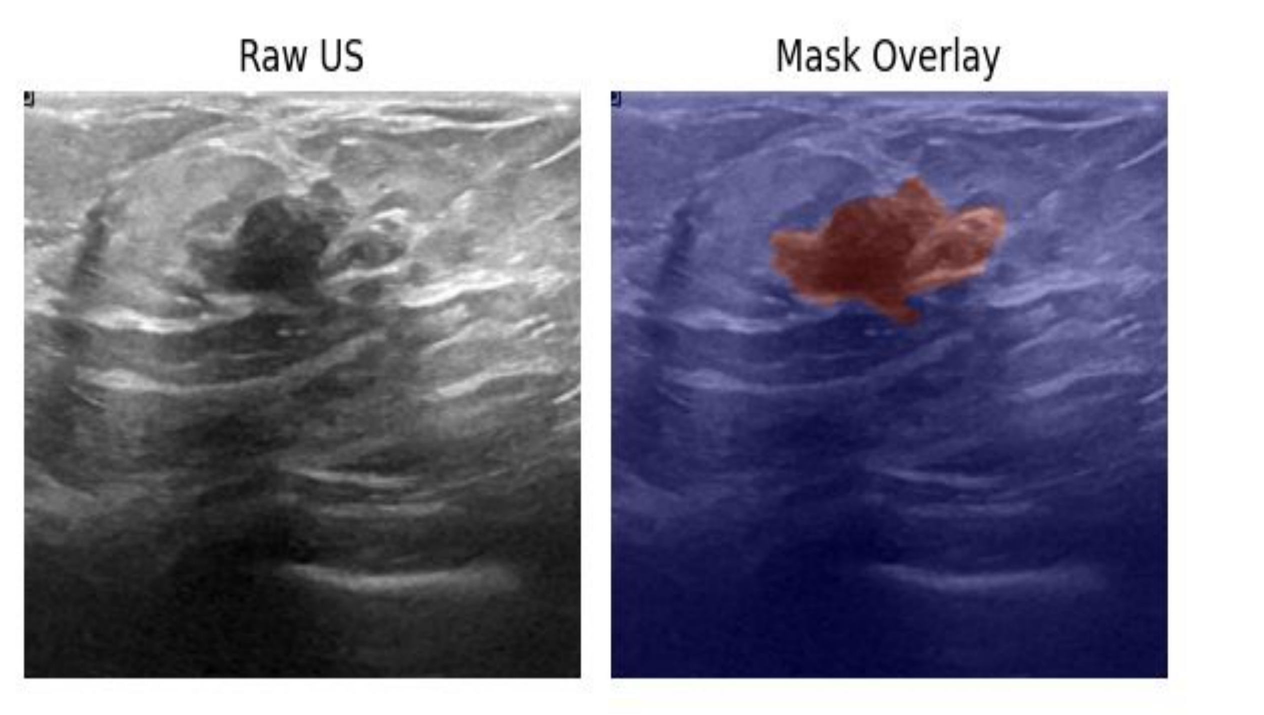
Aim 2

Hypothesis
Using the AI-generated tumor outline as a guide will let our ResNet classifier distinguish subtypes (triple-negative, HER2+, other) with an AUC ≥ 0.85—far above the 0.55 baseline.



- AUC of ROC Curve: Target ≥ 0.85 for each subtype comparison (triple-negative vs. others, HER2+ vs. others).
- Accuracy: Percentage of correct subtype calls.
- Latency: End-to-end inference (mask → subtype) in < 50 ms per image on multiple commercial scanners.
- Cross-Scanner Validation: ≥ 95 % of images processed within the time limit across three different ultrasound machines.

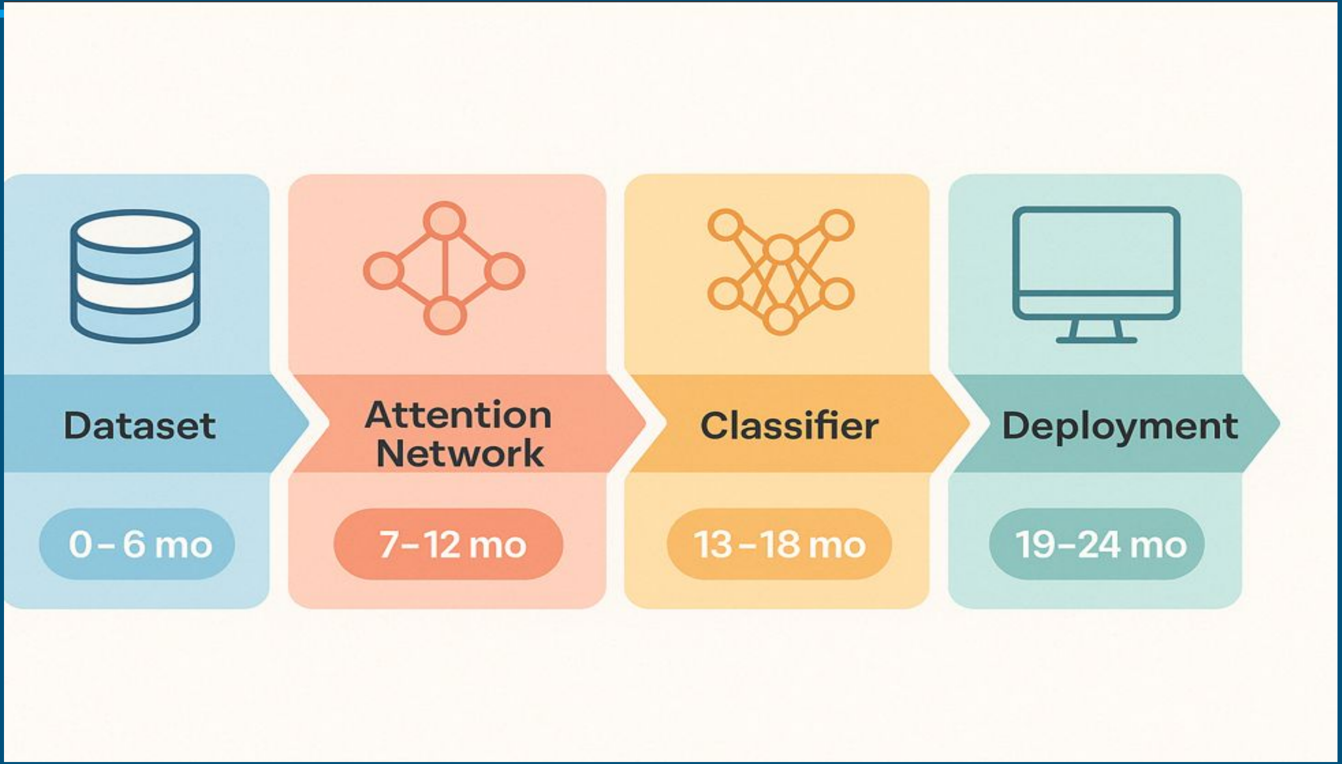
Preliminary Data



Baseline pipeline: crop→lightweight ResNet on N=130

Accuracy 65 %, AUC 0.55 (vs 0.50), 0.11 s/image

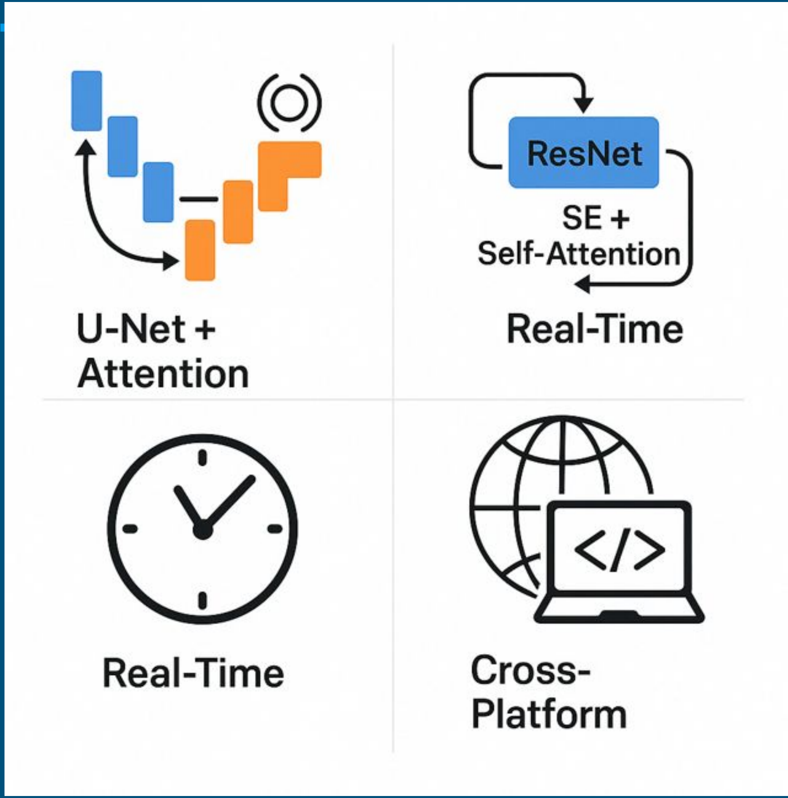
Timeline & Logistics



Broader Impacts

- Reduce false positives & unnecessary biopsies
  – Fewer invasive procedures → less patient anxiety & cost
- Accelerate bedside decision-making
  – Immediate AI-guided insights → earlier intervention
- Democratize care in resource-limited settings
  – Rural/underserved clinics gain expert-level US interpretation
- Foster global collaboration & innovation
  – Open-source models enable adaptation to new diseases/modalities
- Standardize imaging & improve equity
  – Consistent analysis everywhere → fairer access to life-saving diagnostics

Intellectual Merit



- **Interactive GUI/Web App:** One-click attention-guided segmentation + classification wrapped in a user-friendly interface for bedside use.
- **Real-time, cross-platform inference:** Runs in <50 ms/image on varied clinical ultrasound scanners.
- **Open-source** release: Full GUI and codebase published publicly to drive global adaptation and extension.

So Let’s Revolutionize Healthcare with AI-Powered Ultrasound: Precision Cancer Insights in <50 ms

References

1. Ferre R, Elst J, Senthilnathan S, et al. Machine learning analysis of breast ultrasound to classify triple-negative and HER2+ breast cancer subtypes. *Breast Dis.* 2023;42:59–66.

2. Pacal I. Deep learning approaches for classification of breast cancer in ultrasound (US) images. *J Inst Sci Technol.* 2022;12(4):1917–1927.

3. Michael E, Ma H, Li H, Qi S. An optimized framework for breast cancer classification using machine learning. *Biomed Res Int.* 2022;2022:8482022.

4. Becker AS, Mueller M, Stoffel E, et al. Classification of breast cancer in ultrasound imaging using a generic deep learning analysis software: a pilot study. *Br J Radiol.* 2018;91(1083):20170576.