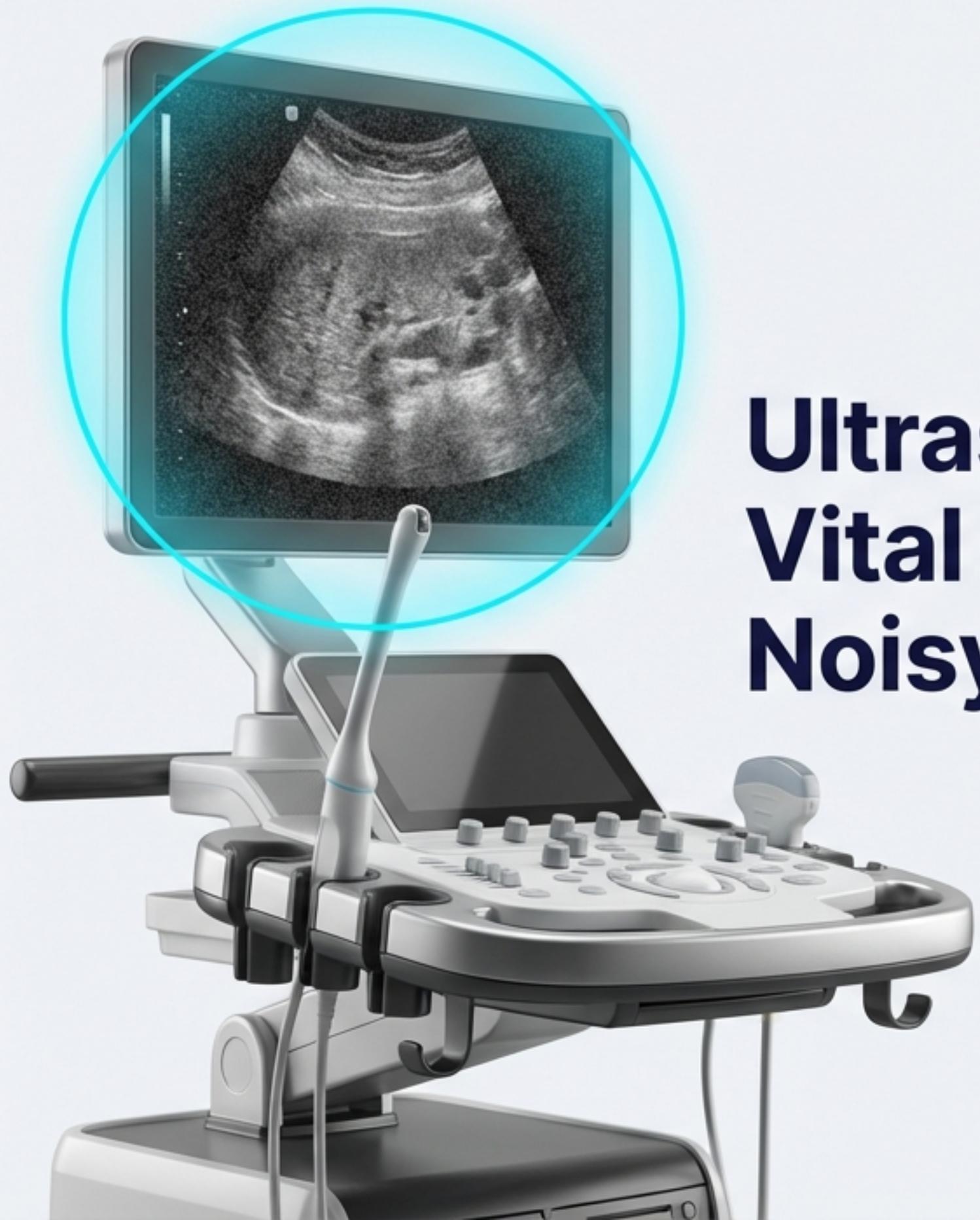


Project Version 1.0 | Alex Chen, M.Eng



Ultrasound: Vital but Noisy



The Gold Standard

Radiation-free, real-time,
and cost-effective.



The Trade-off

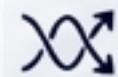
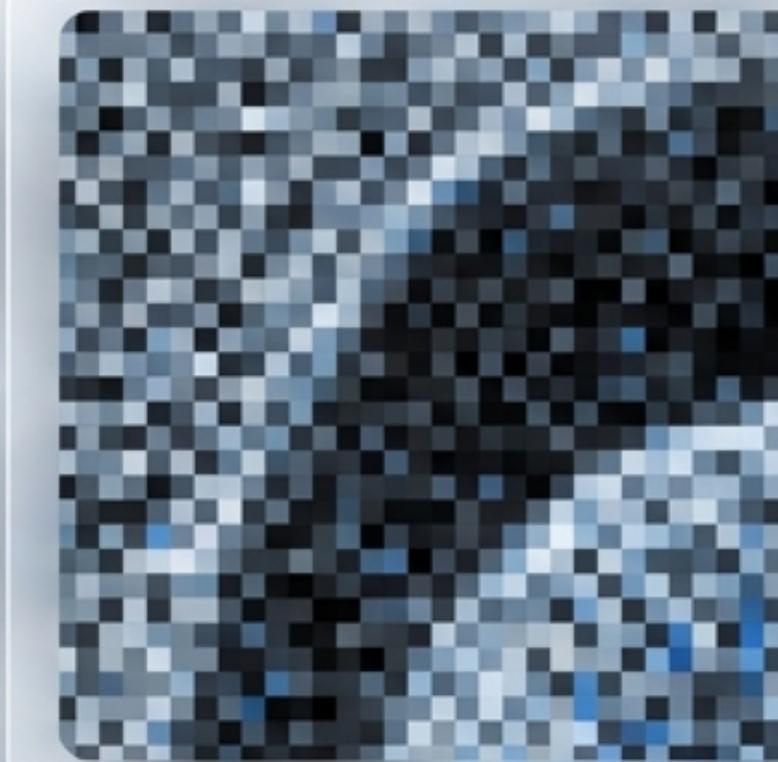
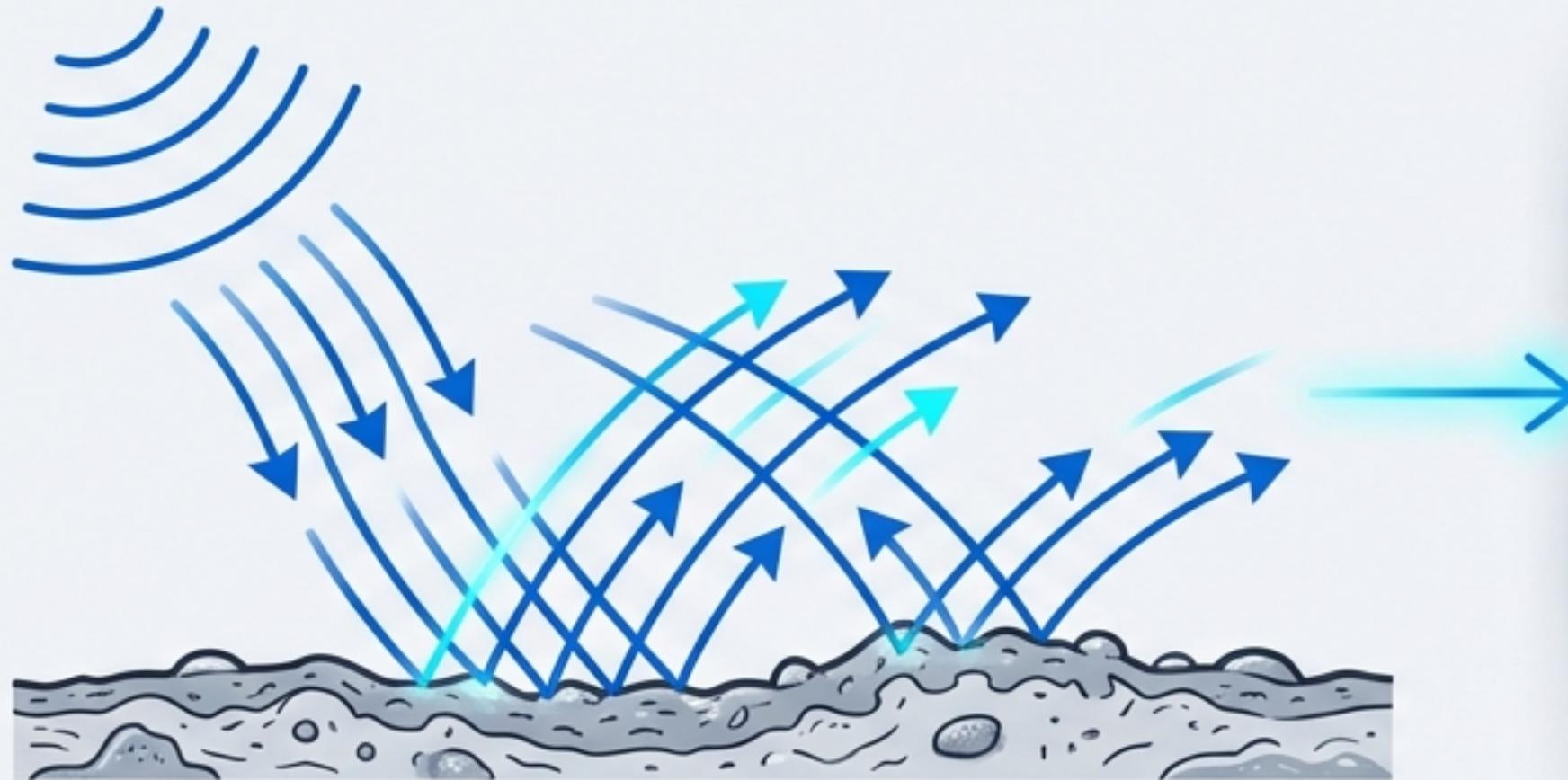
Inherently low contrast
and signal degradation.



The Consequence

Diagnostic confidence drops
when anatomy is obscured.

The Enemy: Speckle Noise



Interference Pattern:

Not just random static, but a granular texture unique to coherent imaging.



Edge Degradation:

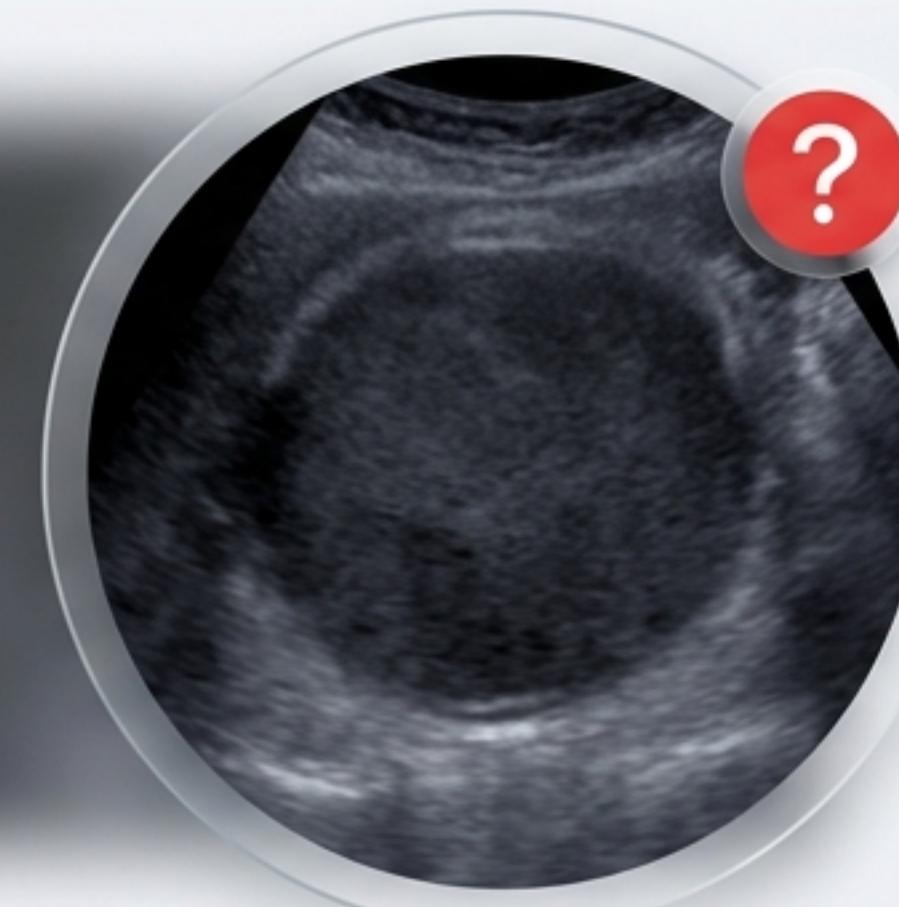
Masks fine tissue structures and blurs boundaries.



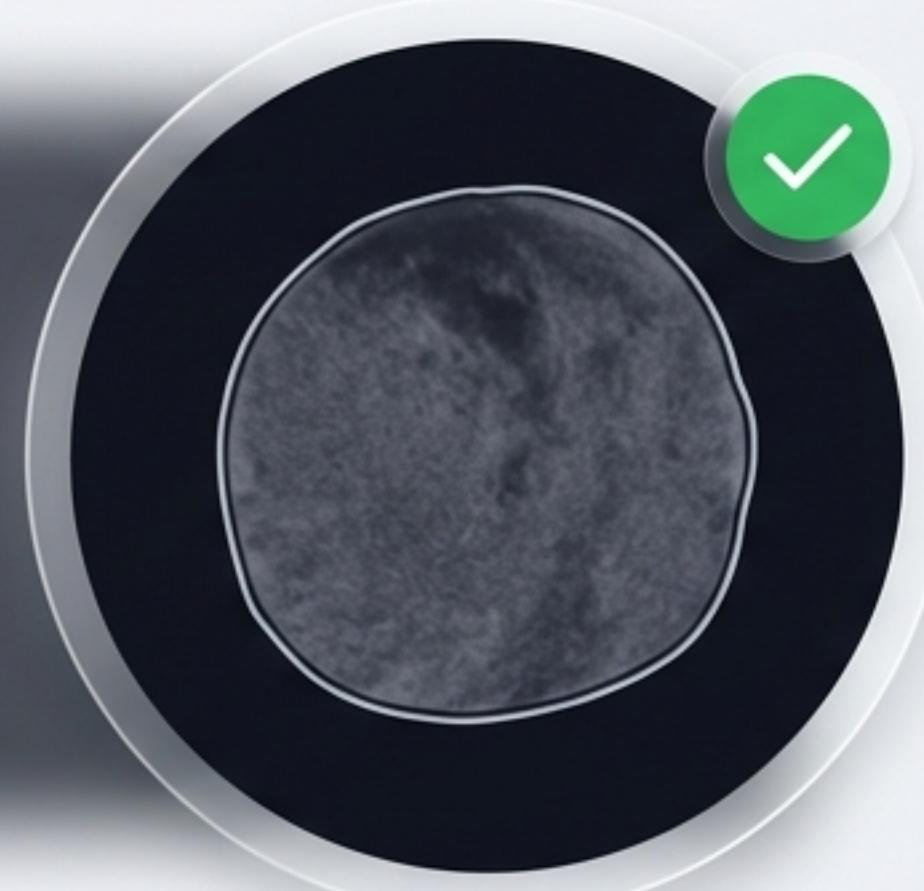
Filtration Challenge:

Traditional filters blur the anatomy while removing the noise.

Clarity Saves Lives



Uncertainty & Fatigue



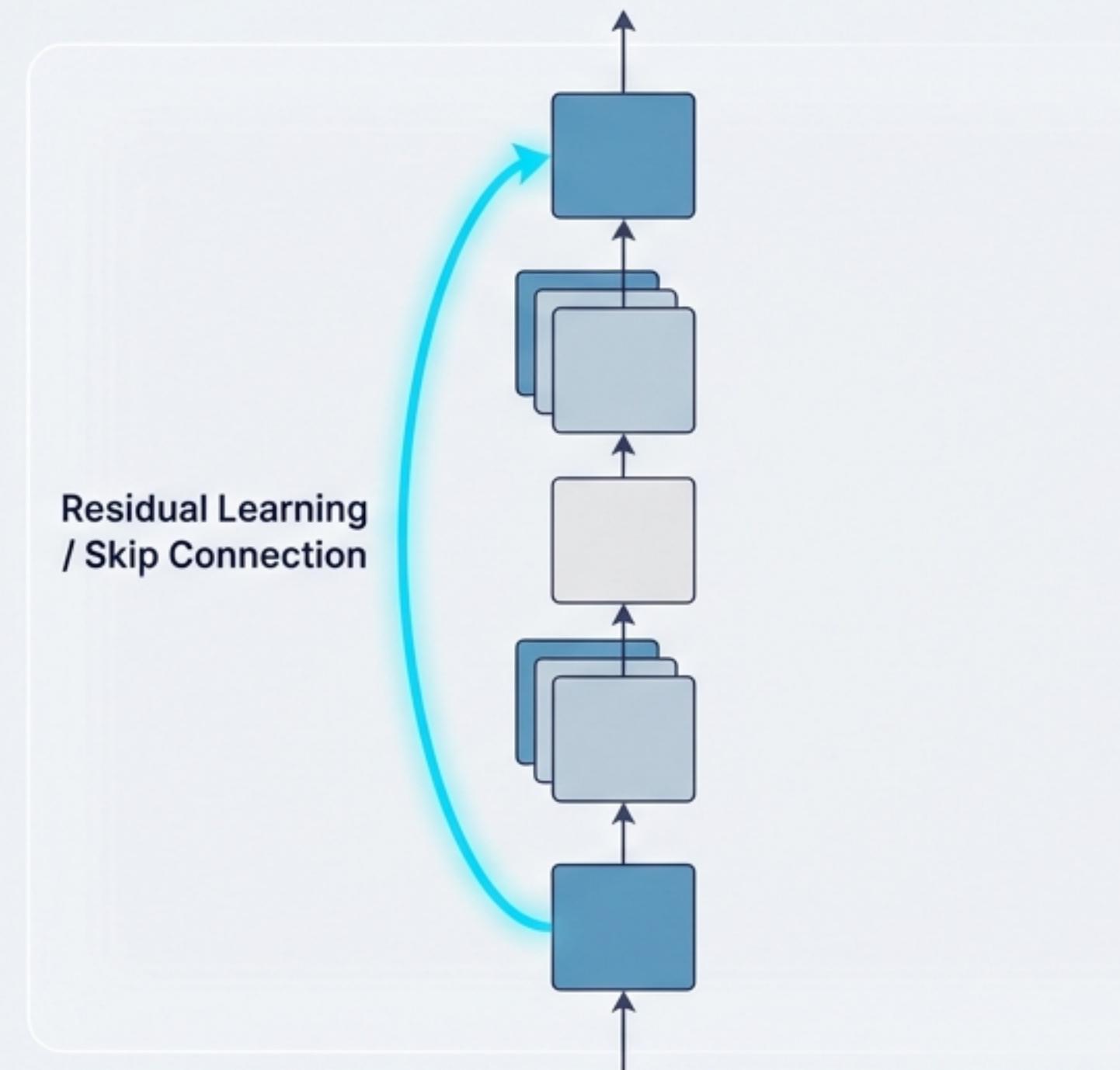
Diagnostic Confidence

Goal: Reveal anatomy, do not invent it.

Hybrid Architecture: Divide & Conquer

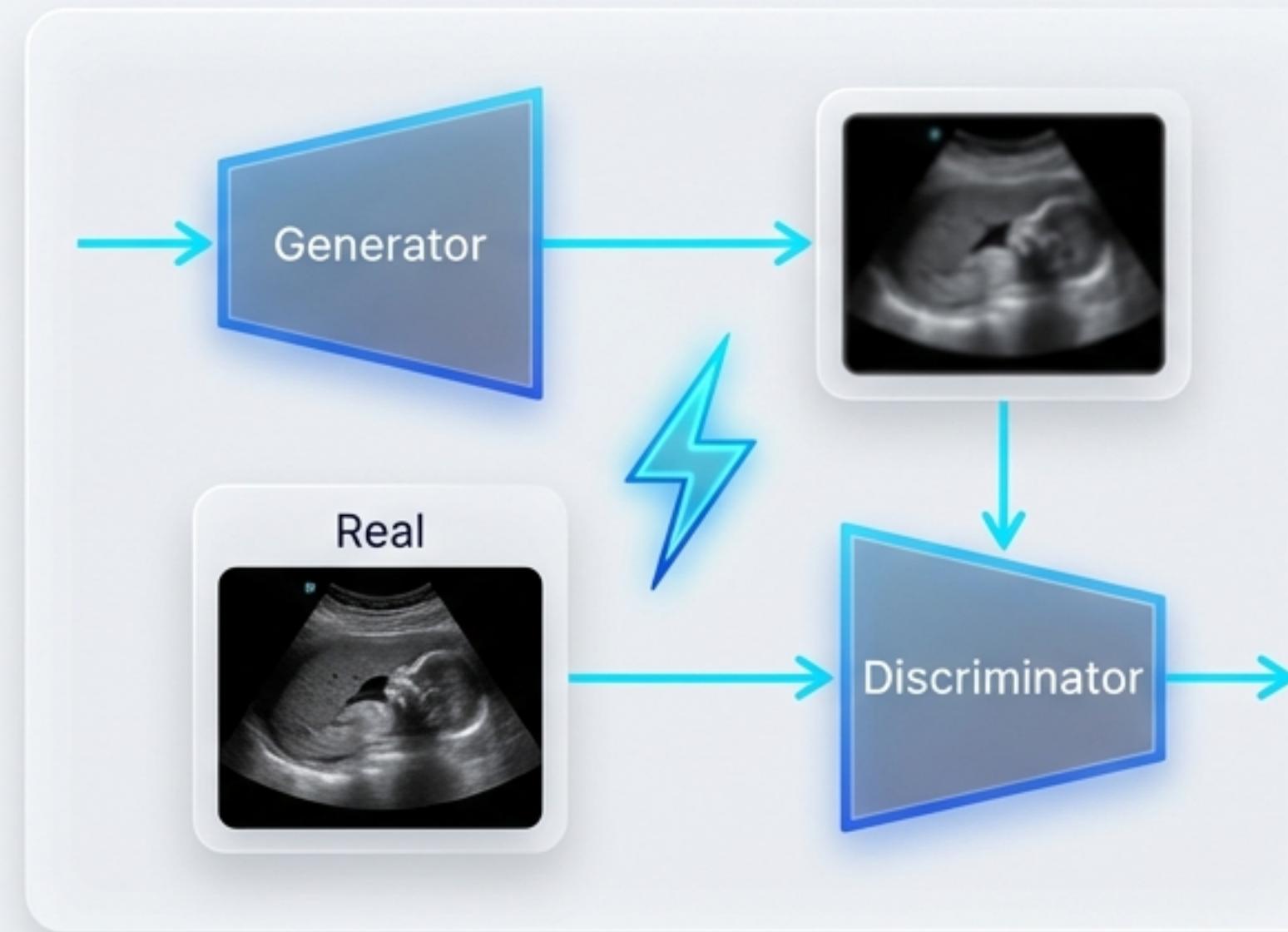


Stage 1: The Cleaner (DnCNN)



- **Framework:** TensorFlow / Keras
- **Mechanism:** Deep CNN separates signal from noise using residual learning.
- **Role:** Removes speckle grain effectively.
- **Result:** A clean, structure-preserved image (often slightly soft).

Stage 2: The Refiner (ESRGAN)

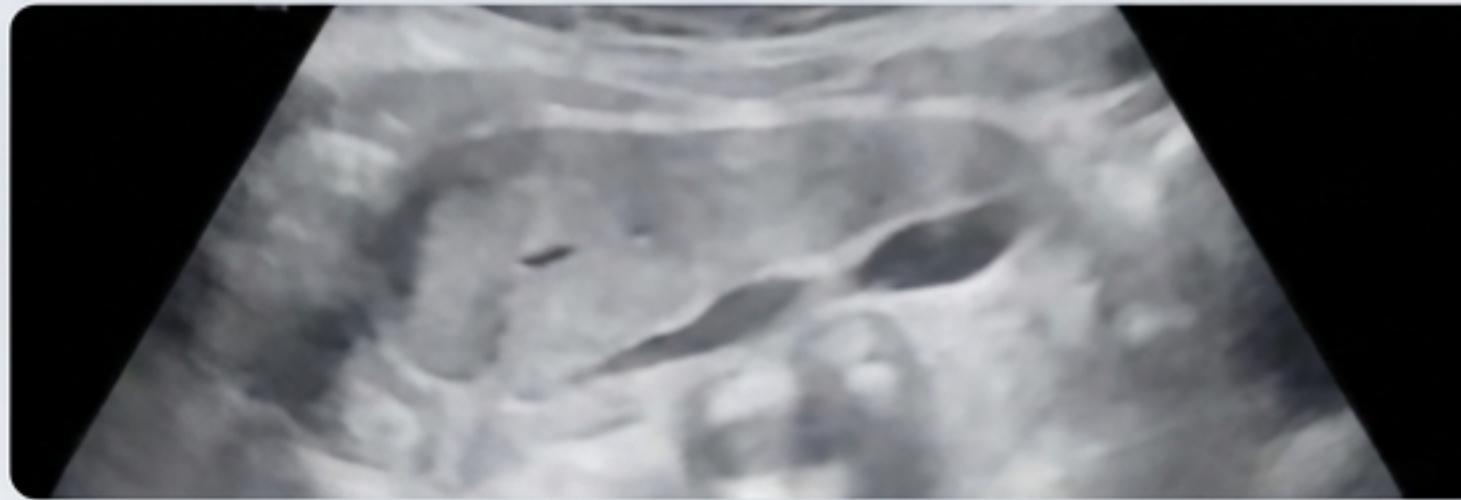


GAN Schematic

- **Framework:** PyTorch
- **Architecture:** Enhanced Super-Resolution GAN (ResNet-based)
- **Configuration:** 1x Scale. (No upscaling, purely refinement).
- **Loss Functions:** L1 + Perceptual (VGG) + SSIM
- **Result:** Restores texture, contrast, and edge definition.

Better Together: The Synergy

DnCNN Only



Clean but Soft

ESRGAN Only

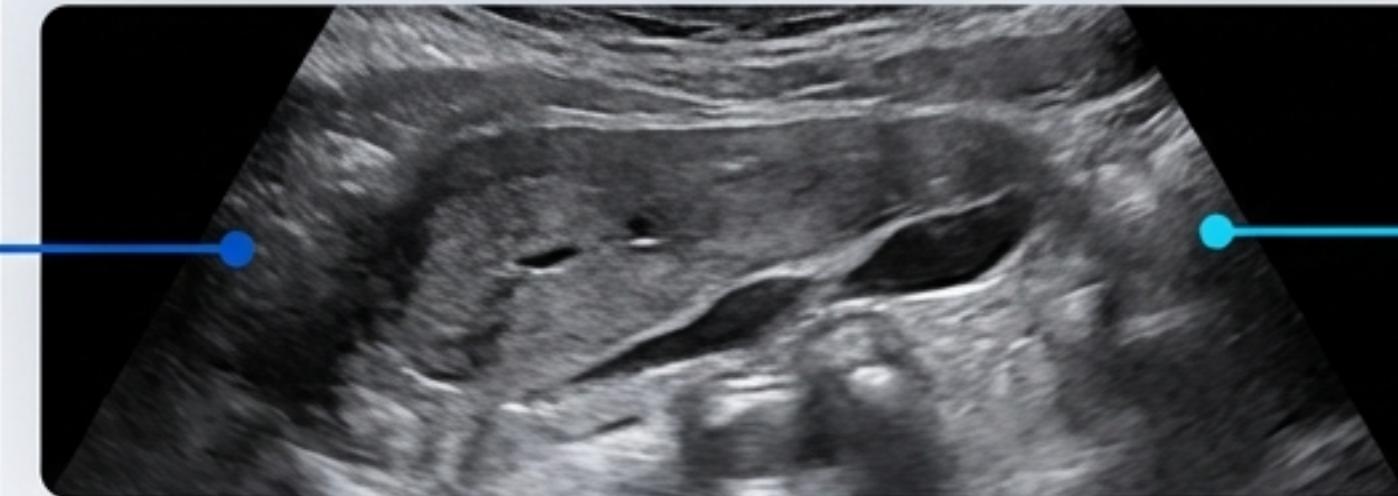


Amplifies Noise

Hybrid Pipeline

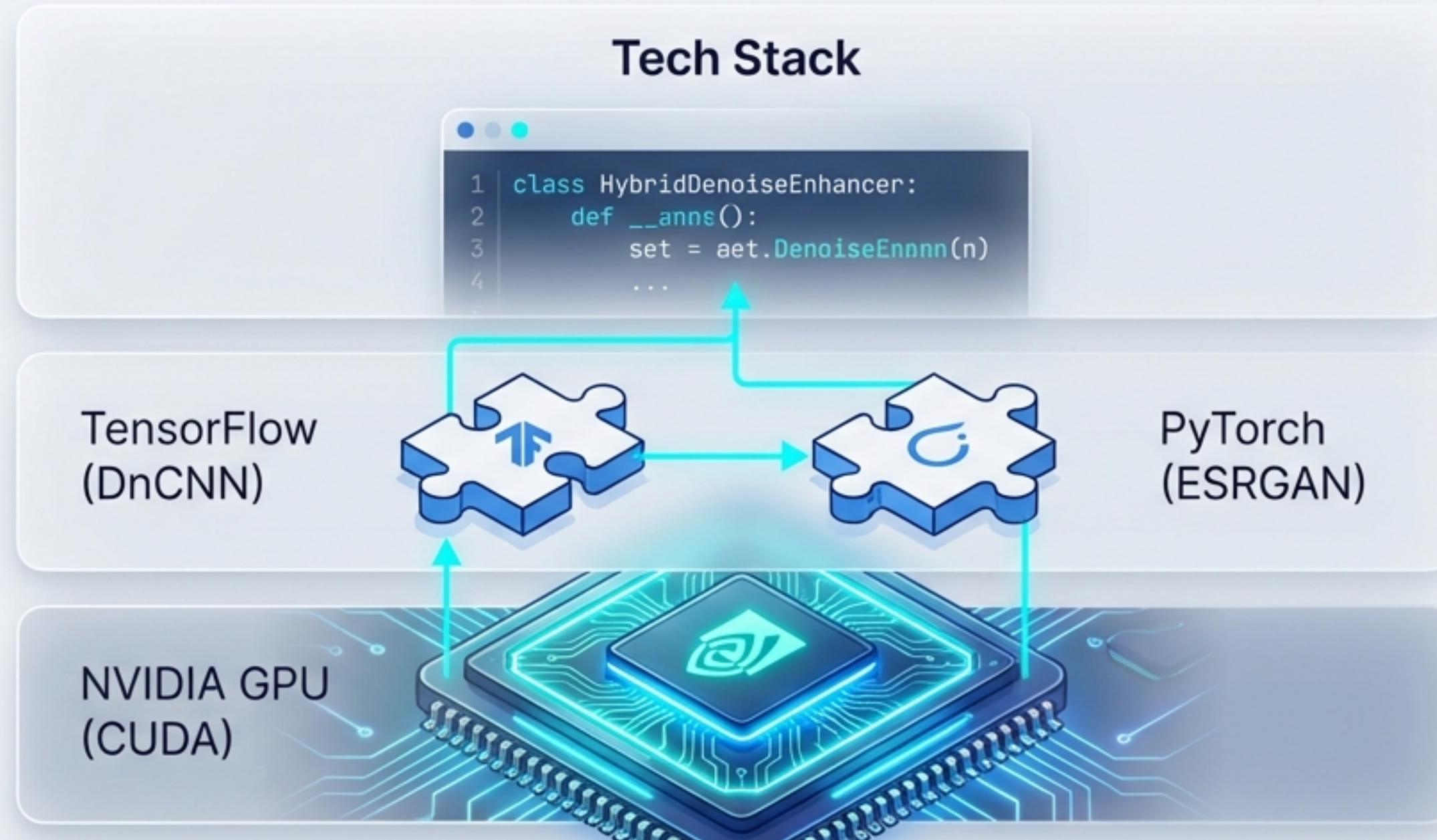
DnCNN cleans the canvas;
ESRGAN paints the details.

DnCNN cleans the canvas;
ESRGAN paints the details.



Clean AND Sharp

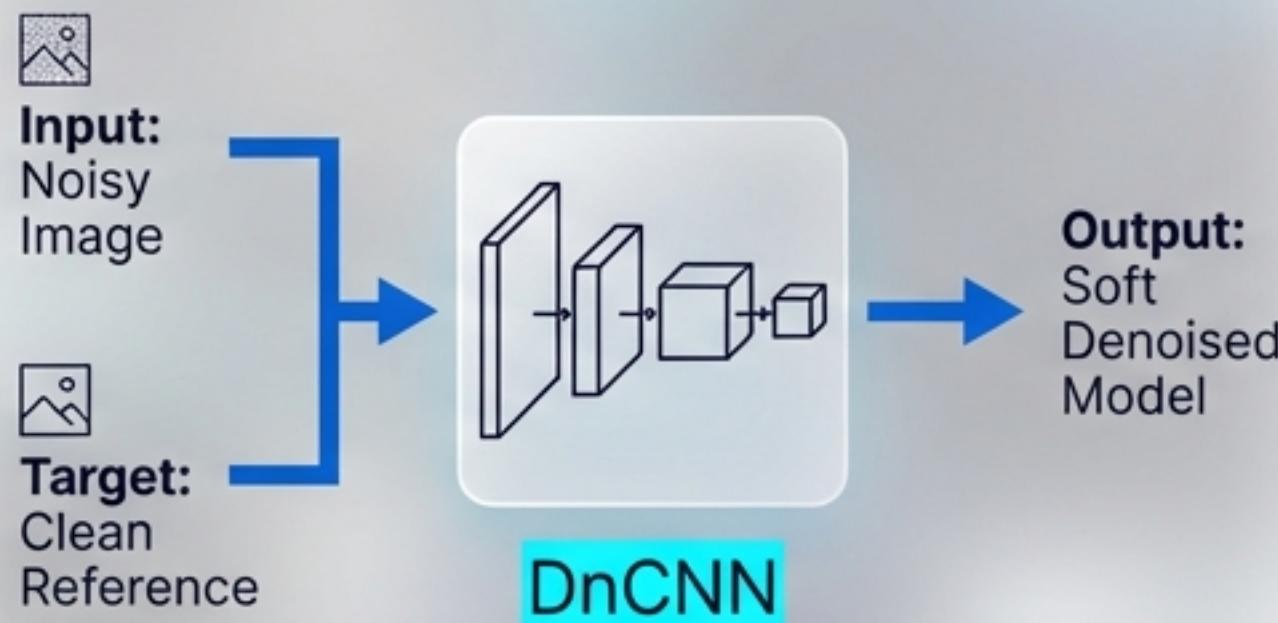
Under the Hood: Implementation



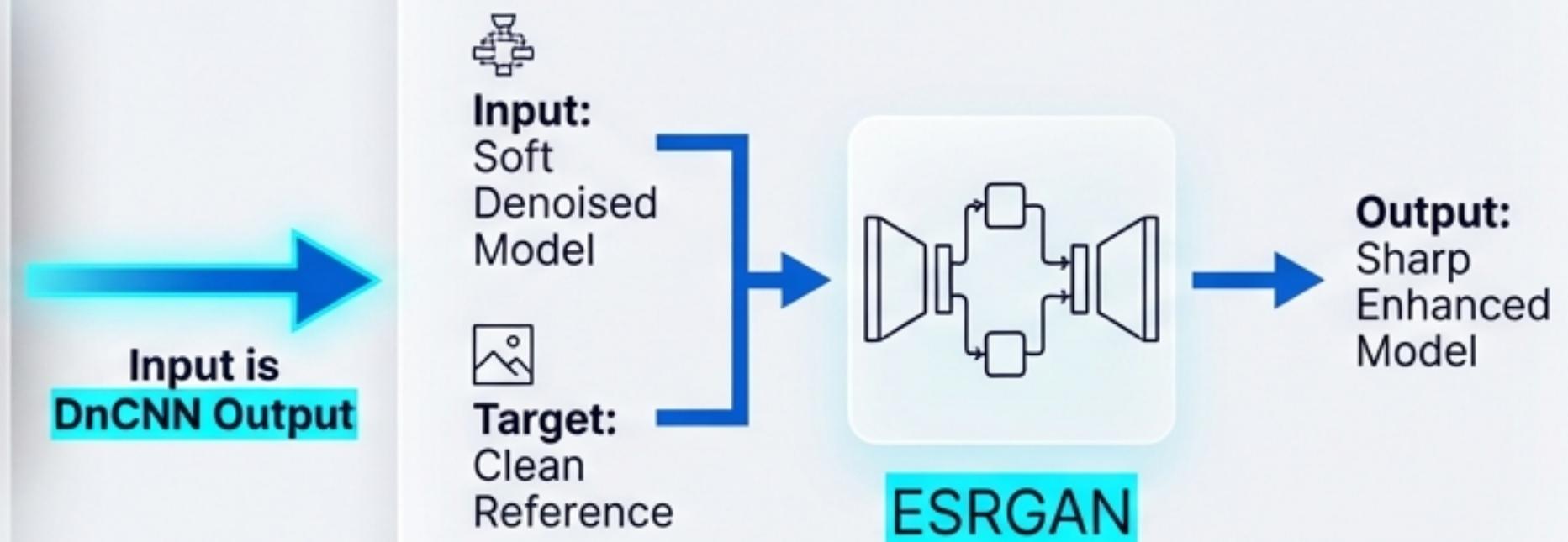
- **Input:** Grayscale [0, 1] Normalized
- **Memory:** Custom VRAM growth management
- **Scripts:** Automated batch processing

Hybrid-Aware Training Strategy

Phase 1: Train DnCNN

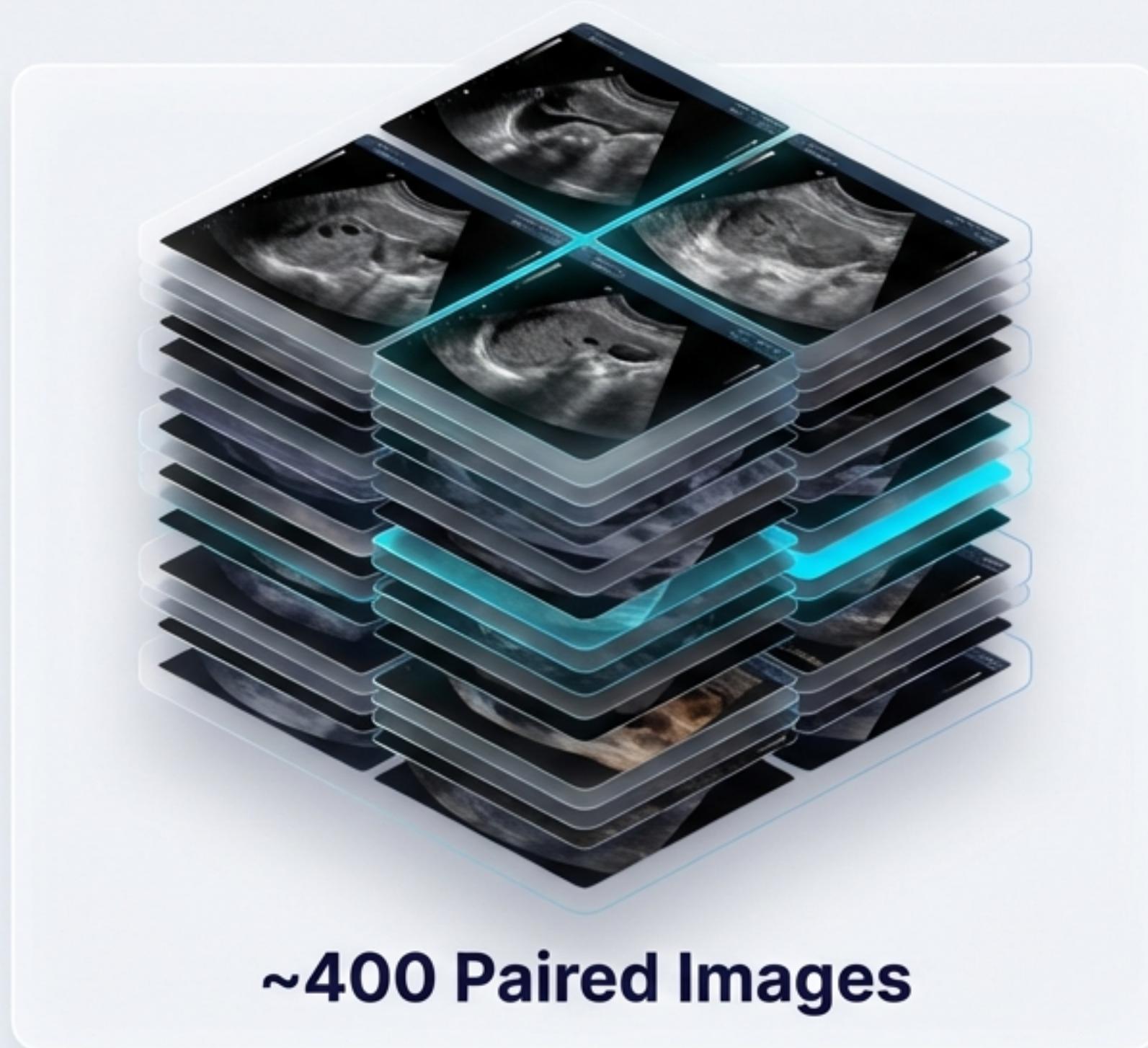


Phase 2: Train ESRGAN



Why? By training ESRGAN on the actual output of the denoiser, it learns to repair the specific “softness” artifacts, preventing domain mismatch during real-world inference.

Data Integrity & Medical Safety



- **The Risk:** Generative models inventing tumors or features.
- **The Safeguard:** Heavy weighting of SSIM Loss and L1 Loss.
- **Validation:** Paired training forces structural honesty over artistic flair.

Quantitative Evaluation Metrics



PSNR (Signal Clarity)

Target: > 30 dB. Measures noise reduction.



SSIM (Structural Accuracy)

Target: > 0.9. Measures anatomical correctness (0-1).

Goal: High PSNR (Clean) + High SSIM (True to Reality).

Results: The Hybrid Advantage

Original Input



DnCNN Output

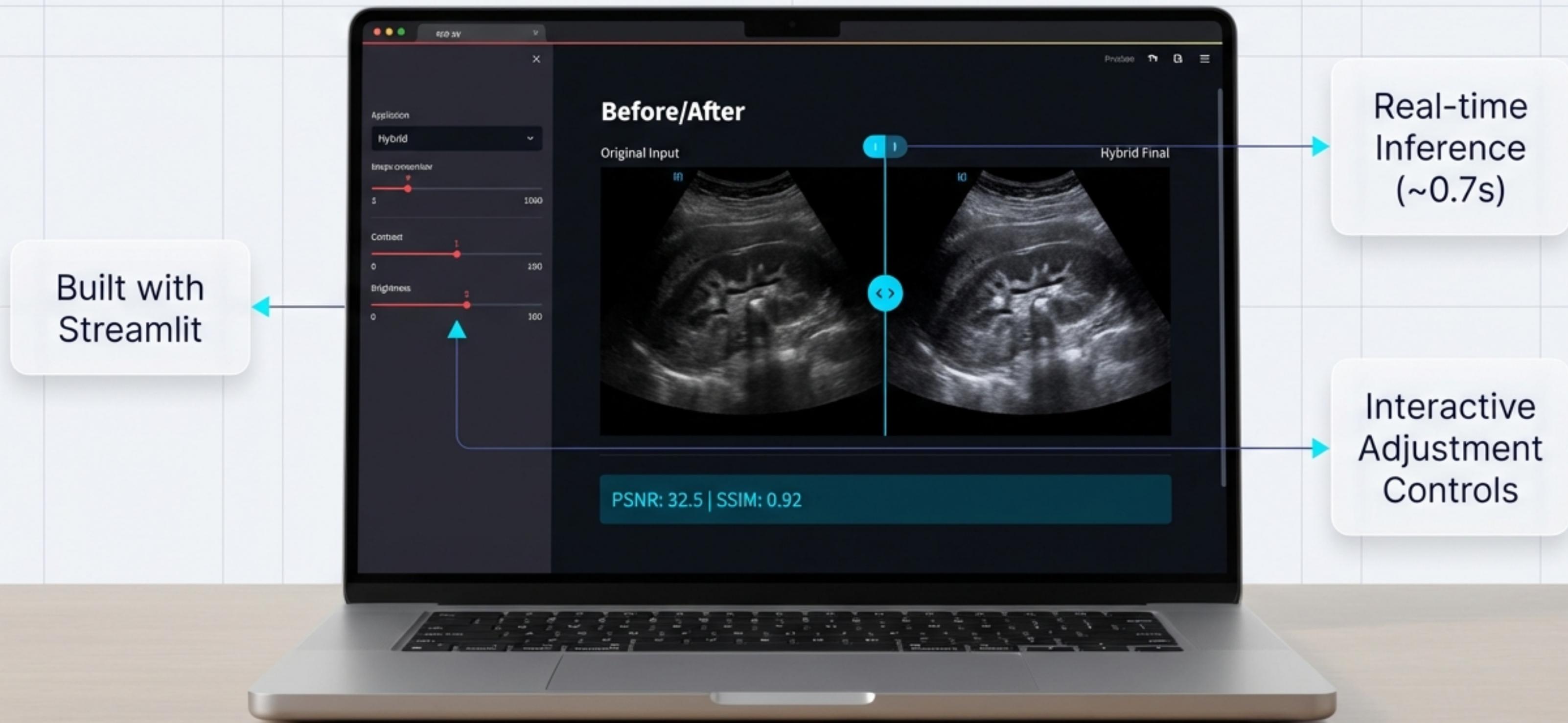


Hybrid Final



- Superior preservation of anatomical boundaries.

The User Experience



Current Limits & The Road Ahead



Current Limits

- Grayscale Only (No Color Doppler)
- Small Dataset (~400 pairs)
- GPU Required for Speed

Future Goals

- Real-time Video Feed
- 3D Volume Rendering
- DICOM File Support

A step forward for accessible, AI-assisted diagnostics.