Tomographic Medical Image Reconstruction with Deep Learning

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Claims
- Medical image reconstruction takes a while – about 5 minutes
- Synthetic SPECT medical data is hard to find
- Our project addresses these issues:
  - Generates large amounts of synthetic SPECT data
  - Uses AI to reconstruct human organ images from SPECT data in milliseconds

Tools Used
- ImageJ – 3D Image Viewer
- ITK-Snap – Image Segmentation Tool
- XCAT – eXtended CArdiac Torso human body phantom, created by Dr. Segars of Duke University
- XCAT+ – Synthetic SPECT images
- OpenGATE – Physics Simulator
- Convolutional Neural Network in PyTorch

System Features
- Data Generator
  - Uses statistics from real patient data
  - Outputs realistic SPECT image ("XCAT+ phantom") and raw data ("sinogram")
- Reconstruction AI
  - Trained on XCAT+ phantom and raw 3D SPECT data from Data Generator
  - Learned to reconstruct artificial SPECT data
  - Experiments with real data

Implementation
- Data generator was largely written in Python
  - Fully automated modular design to call shell commands and other Python programs
- AI was coded with PyTorch, and tested/trained in AI Panther (high-performance computing cluster at FIT)
  - Used (1-SSIM) loss function and SiLu activation function
- Both were modified/refactored from existing code in the lab

System Flow

Input: Synthetic SPECT Image (XCAT+)

Synthetic Raw Data (Sinogram)
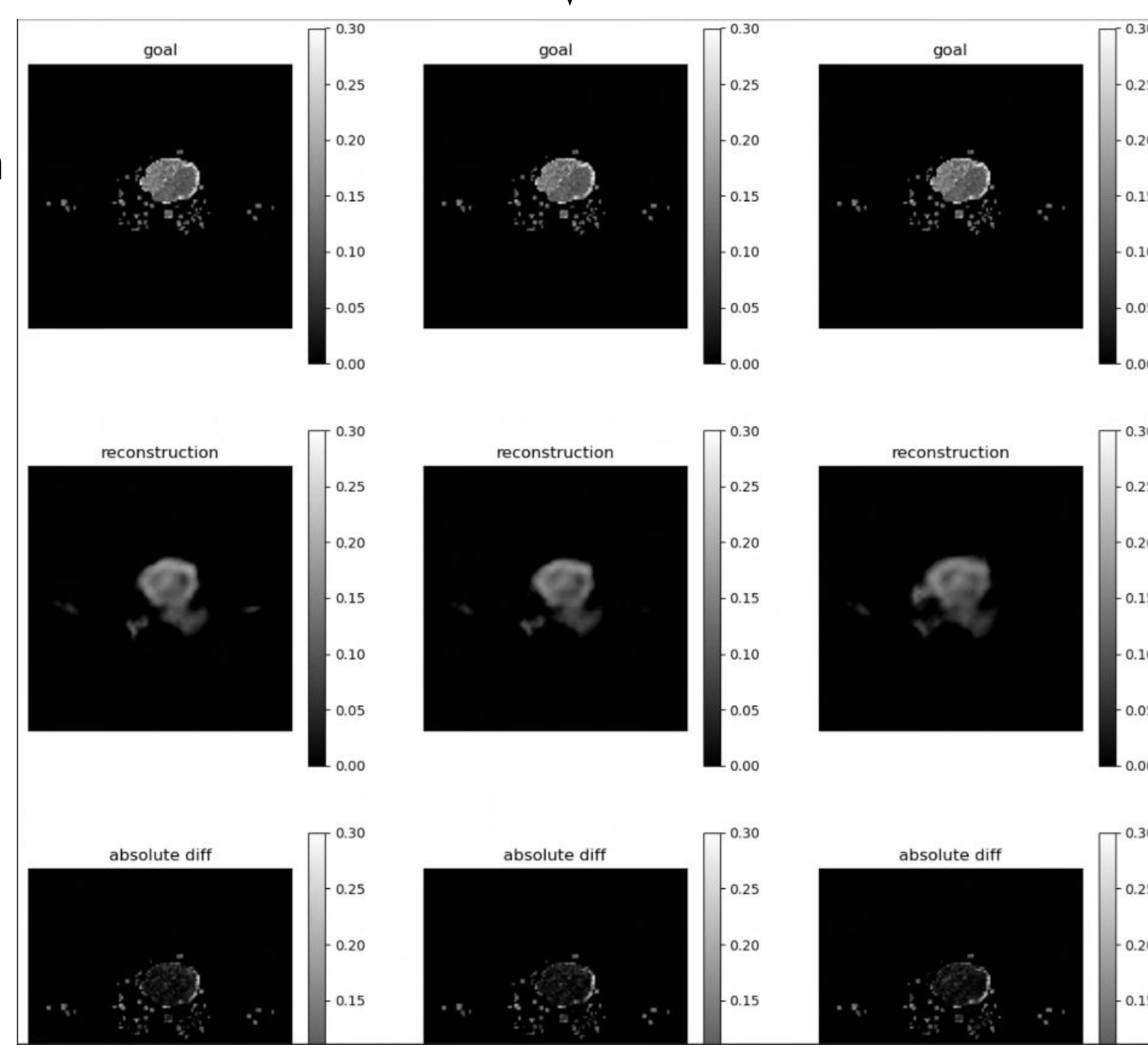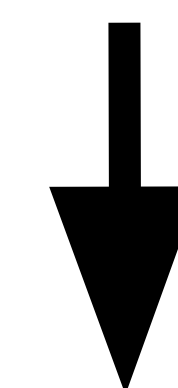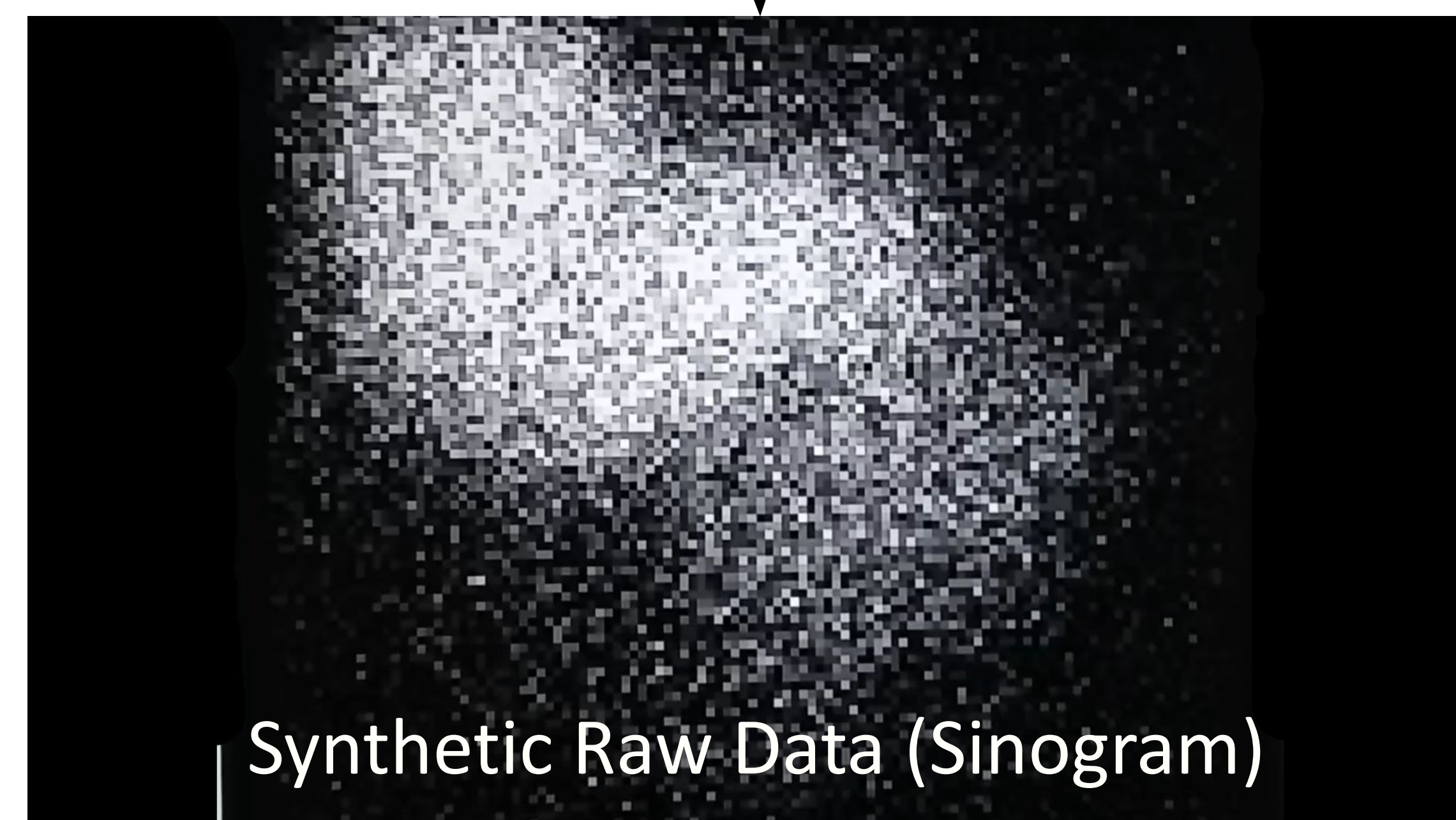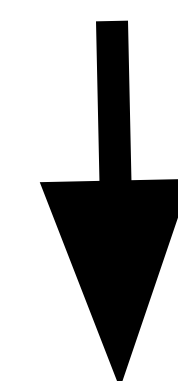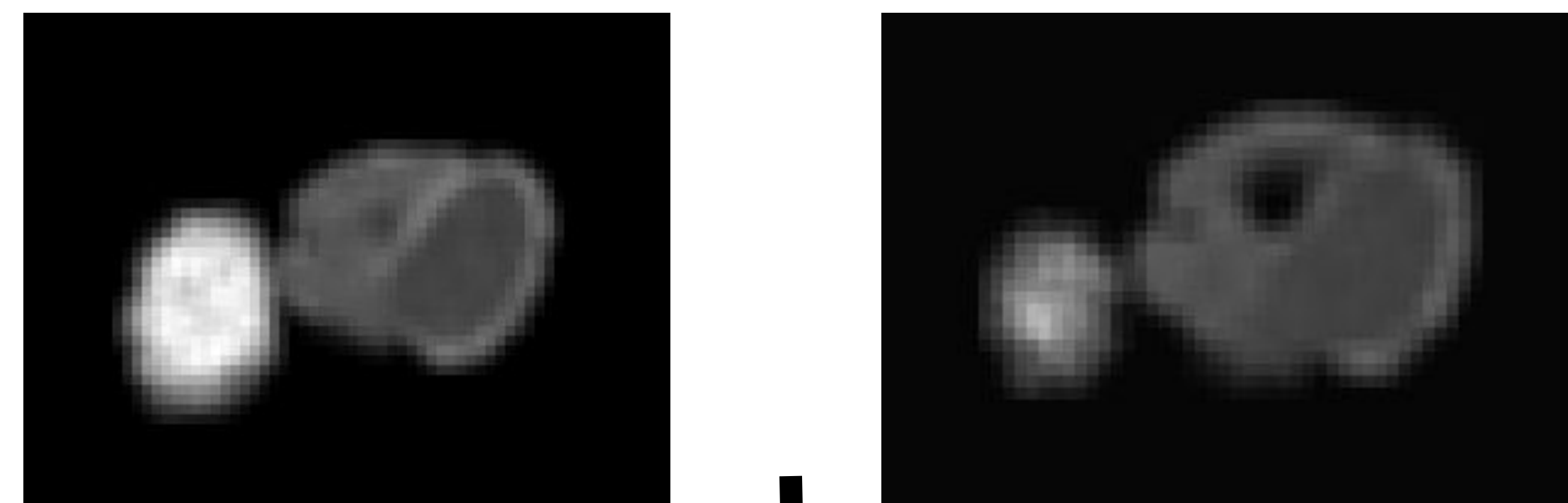
Output: AI Reconstruction of Heart Slices

Evaluation
- How does our data look?
  - Synthetic data is visually similar to real SPECT
  - Only includes heart and liver, but that's okay
    - Those are the relevant parts of SPECT image
- Does the AI work?
  - AI can reconstruct synthetic data with 85% accuracy.

Limitations and Future Work
- Currently, our training is on one GPU which limits how fast we can train. The next group will introduce federated learning to speed up times.
- The reconstructions sometimes appear blurry compared to the desired goal. The next senior project group will try to fix this issue.
- The next senior project group will also try to increase accuracy on real data.

Acknowledgements

References: