# Enabling High Resolution Computed Tomography Neural Representation Using Batched Rays Sampling

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## Introduction and Motivation

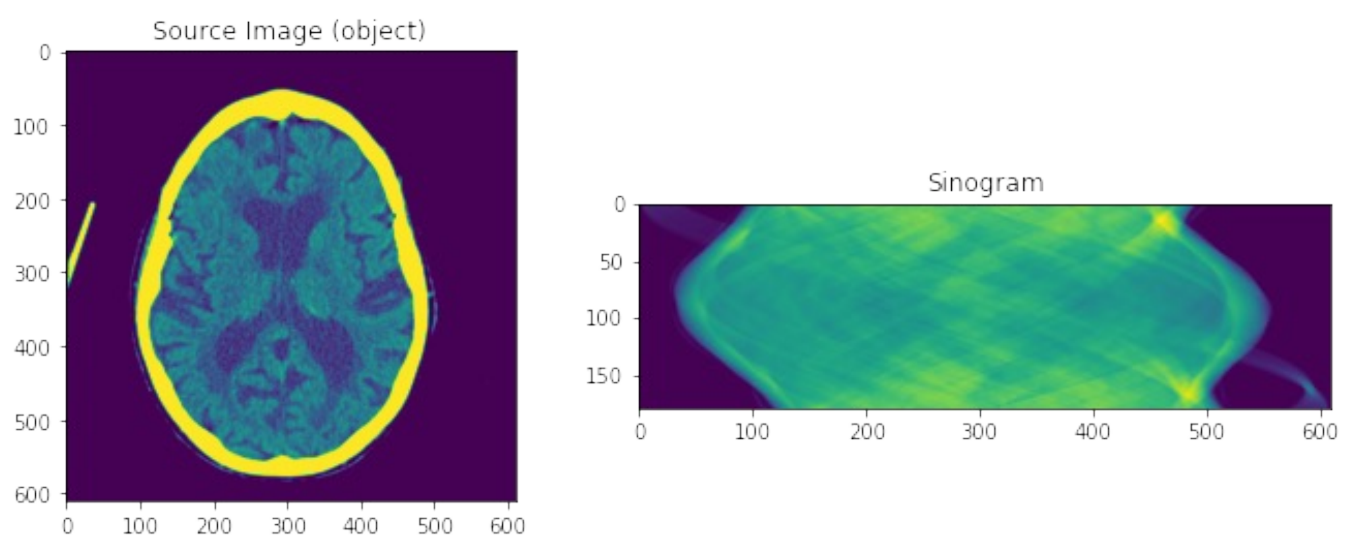


*Figure 1. A CT of a brain (left)[1], and its sinogram from 180 projections (right).*

- Implicit neural representations (INR) have been at the frontier of the computed tomography (CT) reconstruction field.
- Those neural representations require large amounts of GPU memory to be trained, limiting their usage and accessibility.
- We propose a new approach to breaking down the ground truth to enable higher-resolution CT using smaller GPUs. (*Figure 4*)

## Method

- We considered the conventional inverse radon transform as our baseline method for reconstruction. (*Figure 2*)
- The inverse Radon transform, however, conventionally reconstructs the whole image, which makes it memory expensive when fitting it to a neural network. (*Figure 3*)
- We proposed a method to break down the inverse Radon transform into single rays. (*Figure 4*)
- Each pixel in the sinogram space represents a ray (a vector of pixels) in the image space.
- We computed the associated vectors of pixels with every single sinogram pixel and stored them in a dictionary-like data structure.
- While training the network, we could fit as low as one sinogram pixel as our ground truth enabling the training on smaller GPUs.

## Inverse Radon Transform

- Radon Transform (*Eq1*)

$$F(\alpha, s) = \int_{-\infty}^{\infty} f(t\sin\alpha + s\cos\alpha, -t\cos\alpha + s\sin\alpha)\, dt$$

- Inverse Radon Transform (*Eq2*)

$$f(x, y) = \int_{0}^{2\pi} F(\alpha, x\cos\alpha + y\sin\alpha)\, d\alpha$$

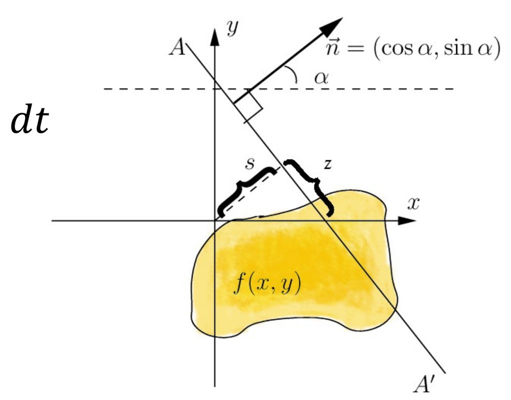


*Figure 2. Radon transform. Maps f on the (x, y) domain to Rf on the (α, s) domain.[2]*

## Proposed Pipeline

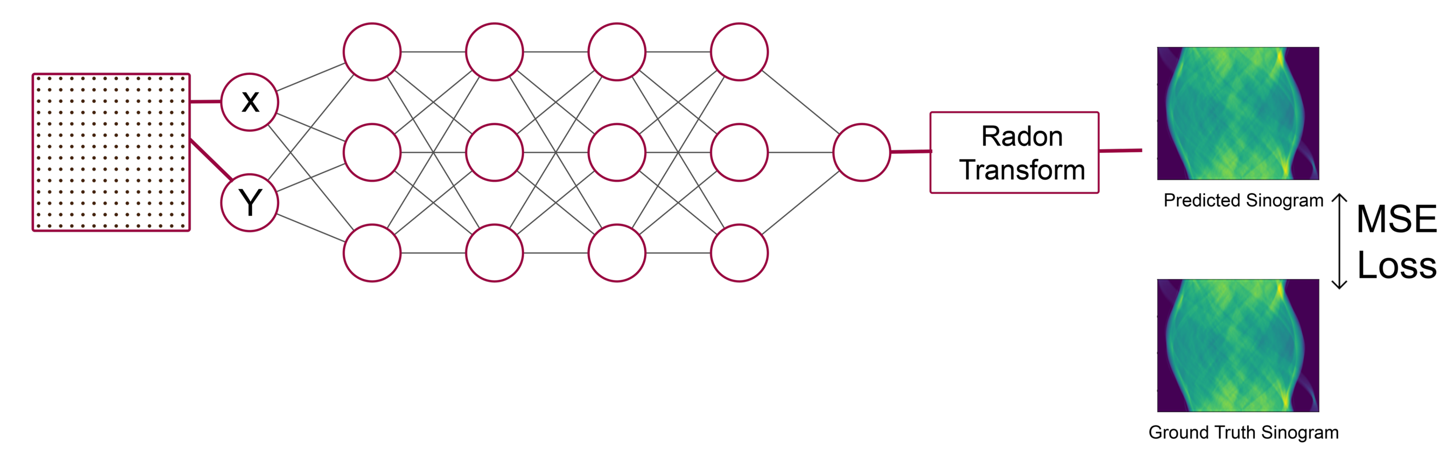


*Figure 3. Traditional implicit neural network for computed tomography. Input: 50% of the coordinates of the desired CT image.*

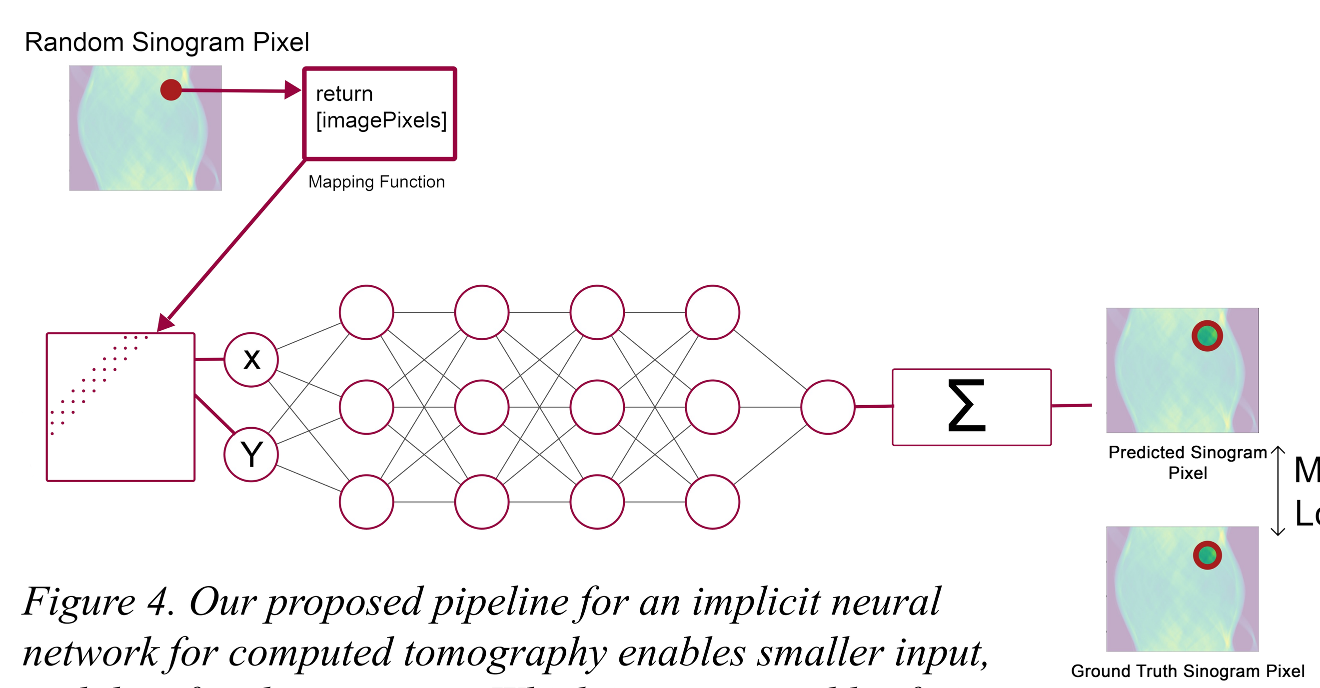


*Figure 4. Our proposed pipeline for an implicit neural network for computed tomography enables smaller input, and therefore less memory. Which in return enables fitting higher resolution CT.*

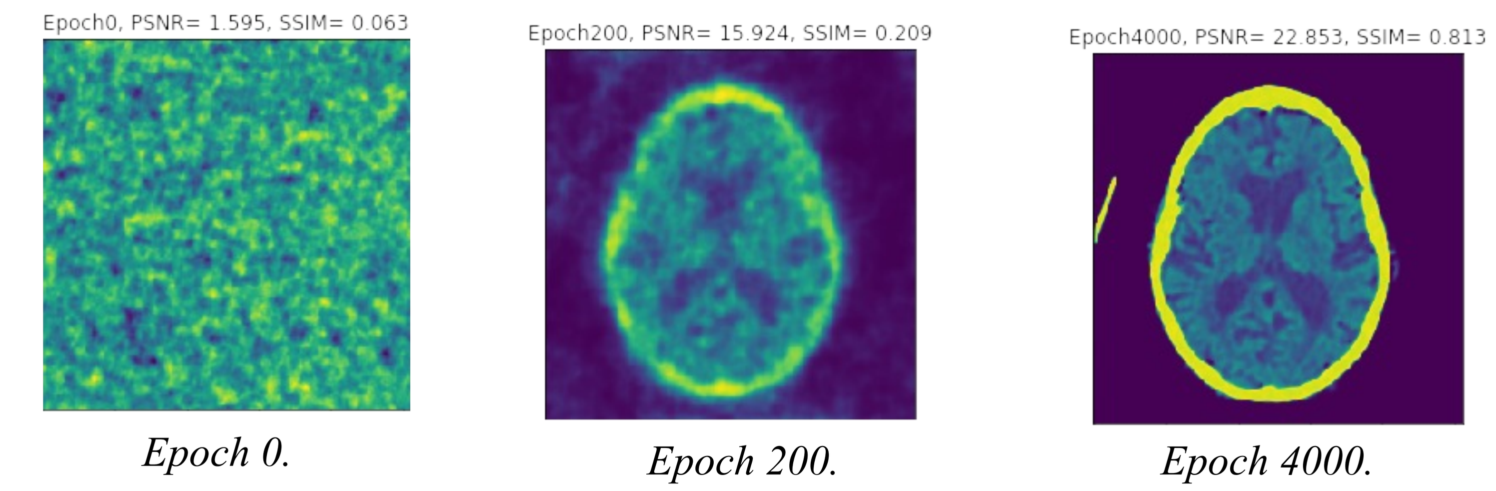


*Figure 5. Reconstructed CT images from our proposed pipeline with 200 sinogram pixels/iteration. Images shown are from epoch 0, 200, and 400. The ground truth CT image and sinogram are shown in figure 1.*

## Conclusion and Future Work

- Our proposed method has enabled high-resolution computed tomography representations in neural networks with conventional GPUs.
- The method is yet to be expanded to 3-D where more applied problems can be addressed.
- The ray (sinogram pixels) sampling method (random vs non-random) is still being evaluated.
- Additional priors can be incorporated to study their effects on the reconstruction quality.

## Acknowledgement

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## References

[1] Karim, Shanyar Hama. "Subcortical Heterotopia | Radiology Case | Radiopaedia.org." Radiopaedia, radiopaedia.org/cases/subcortical-heterotopia-3?lang=us. Accessed 11 Apr. 2022.
[2] "Radon Transform." Wikipedia, 8 June 2021, en.wikipedia.org/wiki/Radon_transform. Accessed 11 April 2022.