Sinogram Synthesis using CNN for Sparse CT Reconstruction

Swapnil Vekhande

Electrical and Computer Engineering

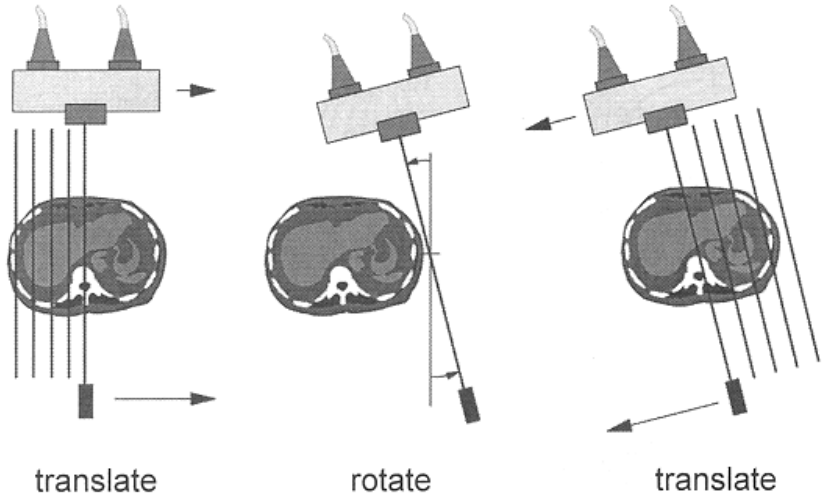
Introduction

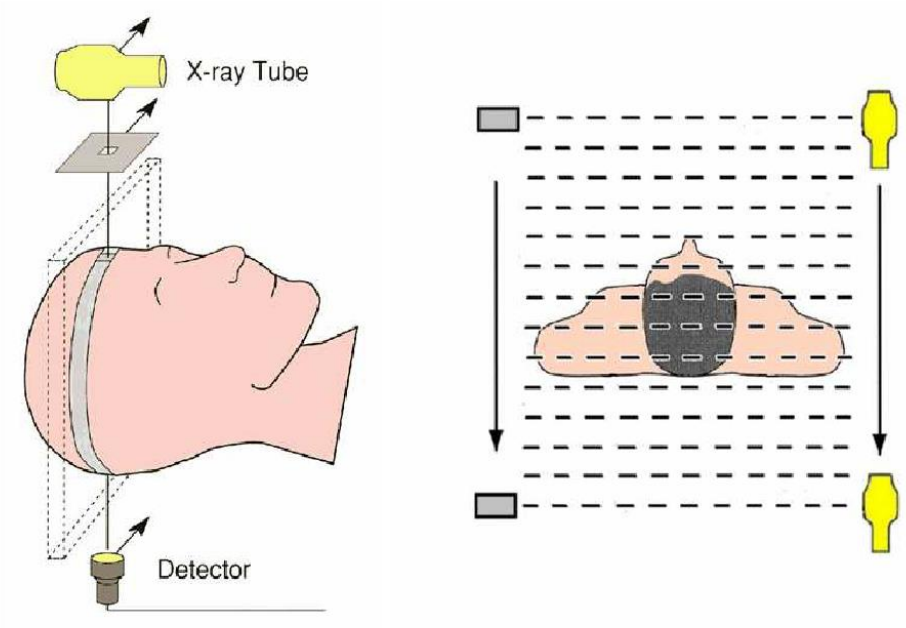
- Computed tomography (CT) is a widely used medical imaging modality for showing anatomical structures such as lung and bones.
- On the other hand, concerns about radiation dose with CT examination has also been increasing due to potential risk of cancers.
- However, reducing radiation dose is inevitably leads to increased Signal-to-Noise ratio(SNR) causing misdiagnosis in CT images.

Problem Statement

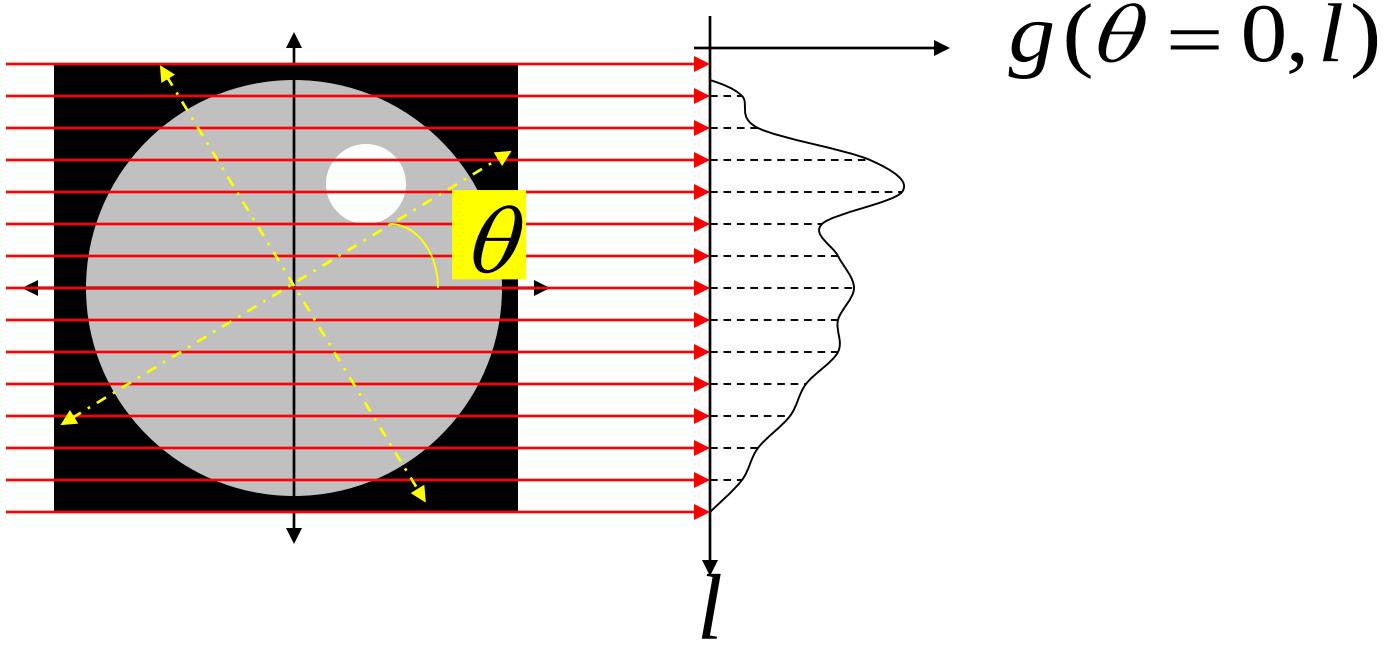
- Effective interpolation of Sparse CT projection data while preserving adequate image quality is crucial in reducing radiation dose in CT imaging.
- This is a classical ill-posed inverse problem in imaging.
- Deep Learning can be used to learn the distribution of sparse samples and make predictions about the missing angles by comparing with the ground truth

CT Scan

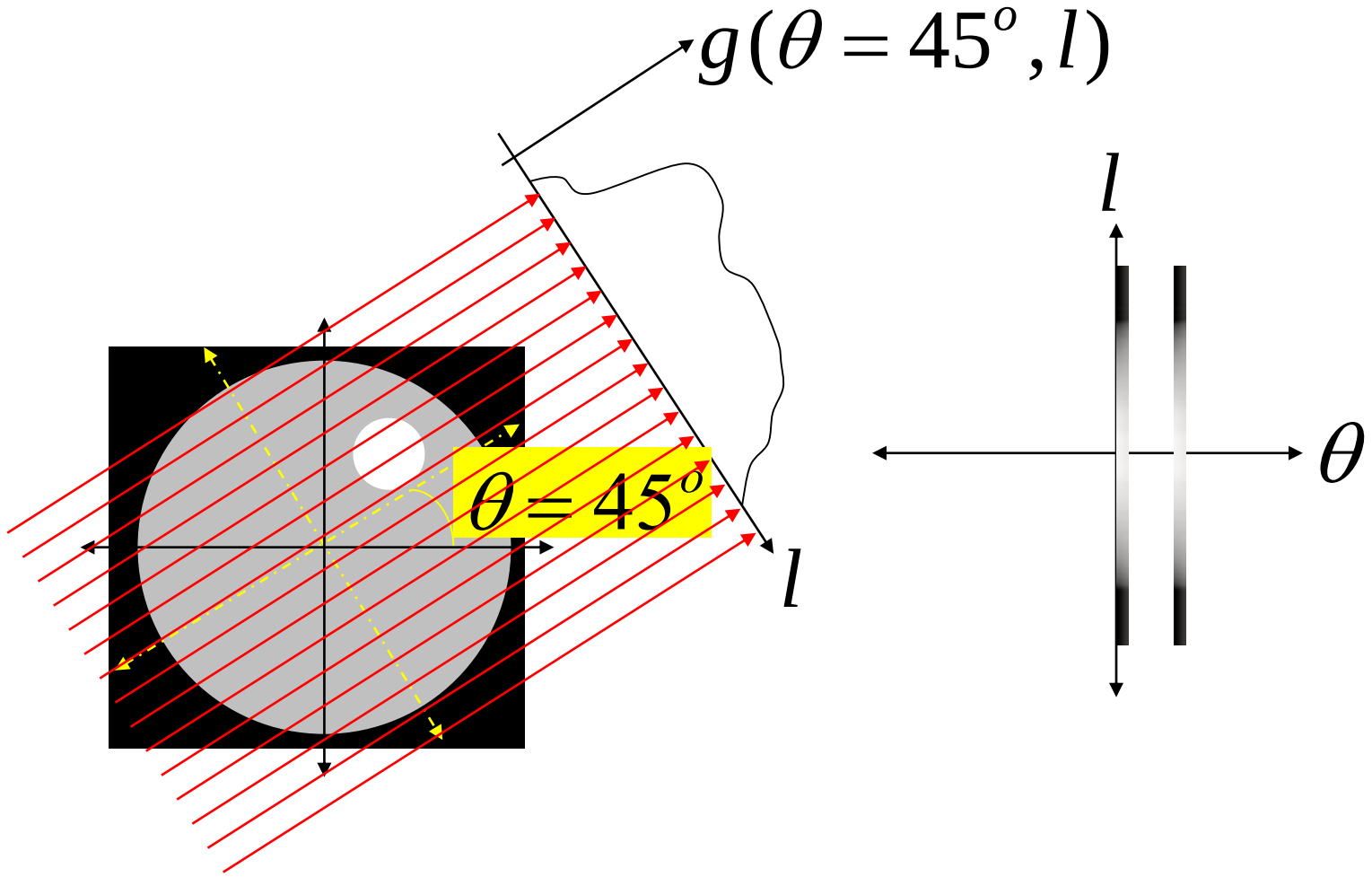




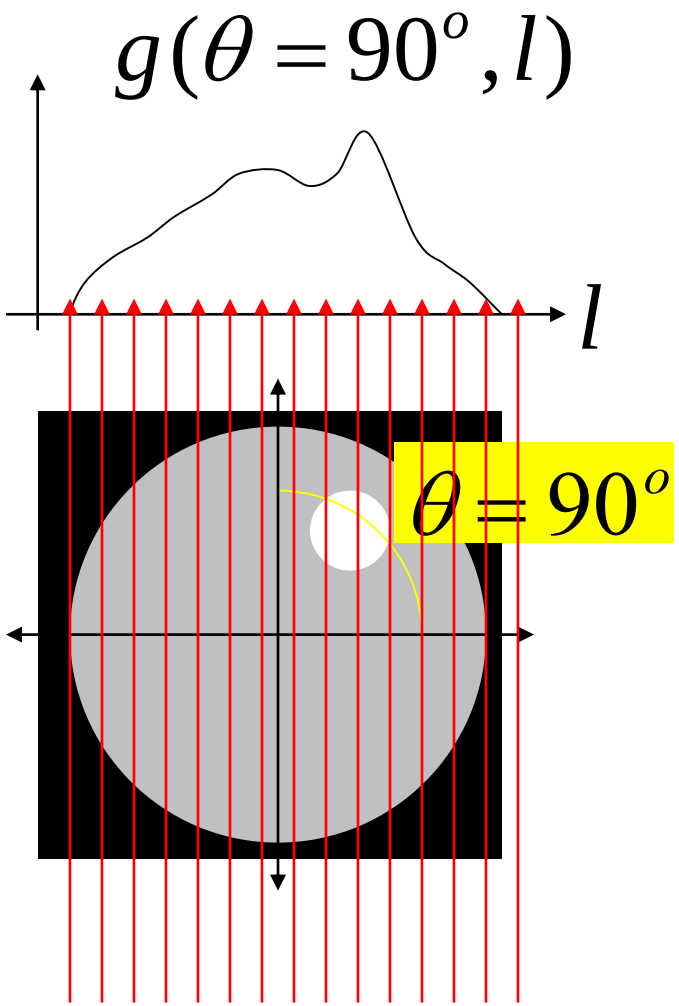
How Sinogram is generated?

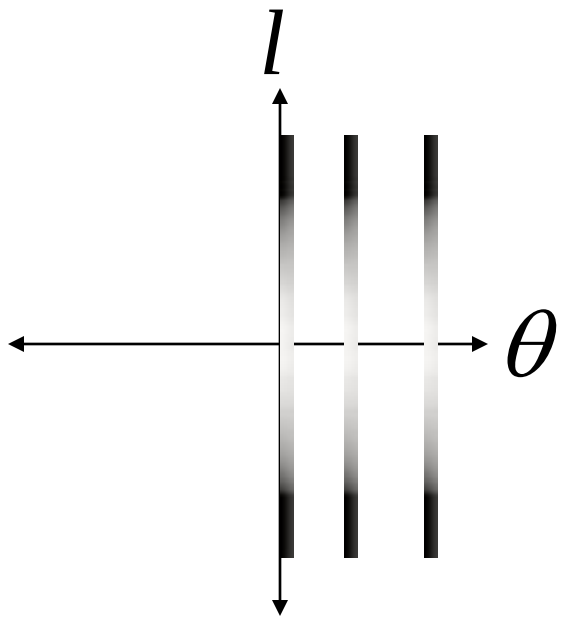


Rotate and Take Projections

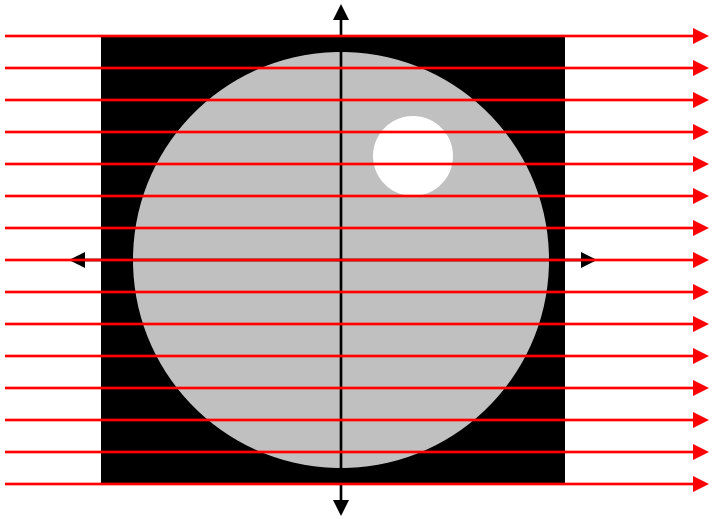


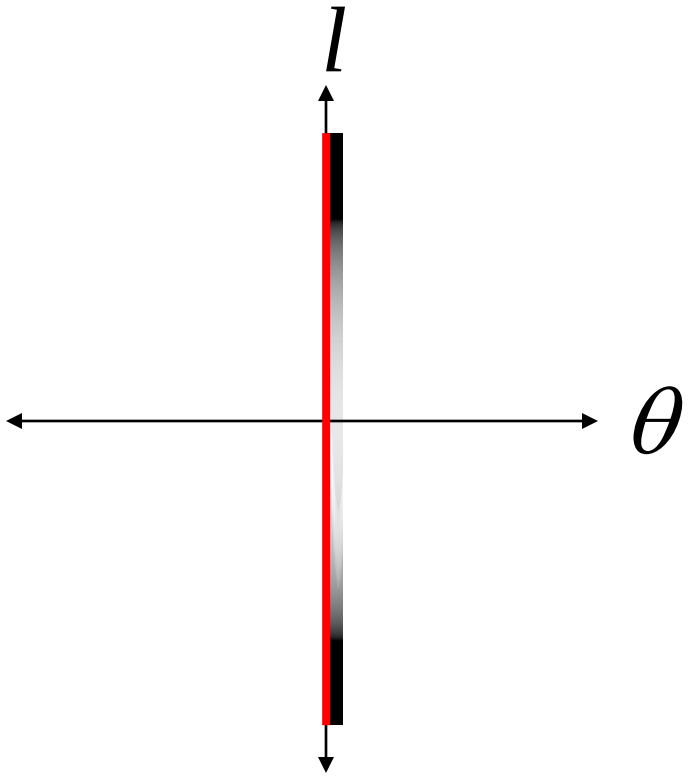
Rotate and Take Another Projection





Sinogram Generation





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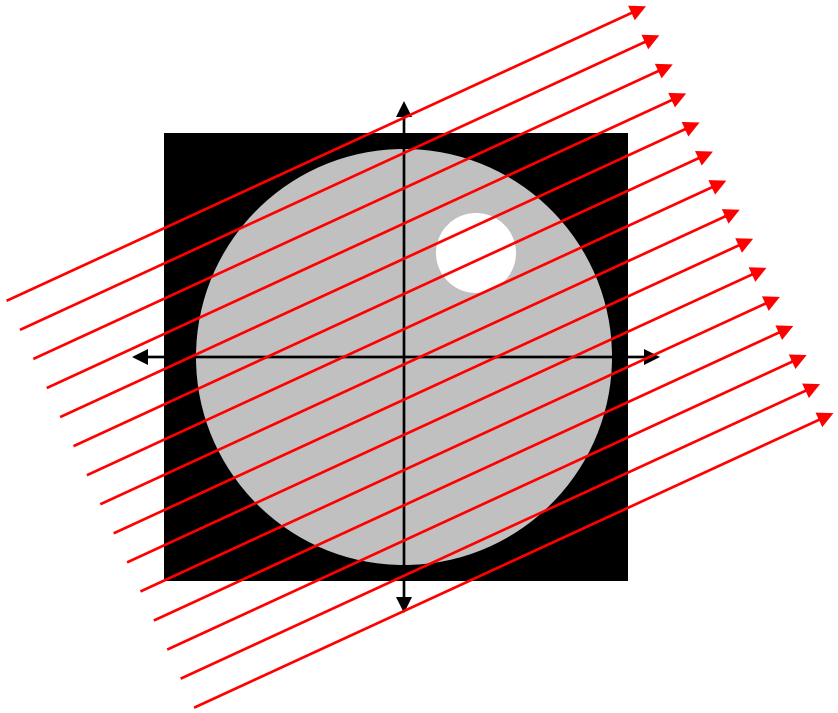

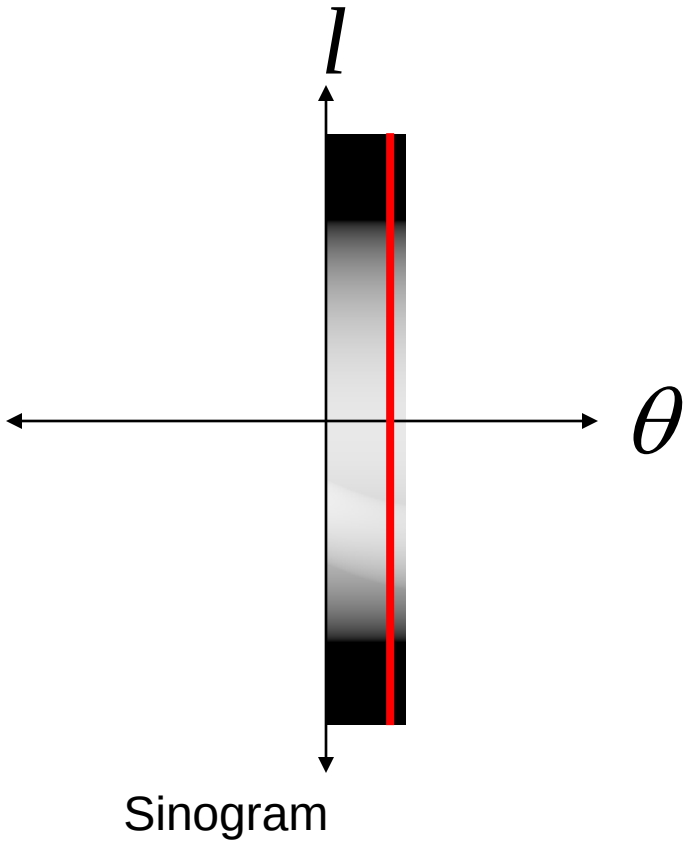

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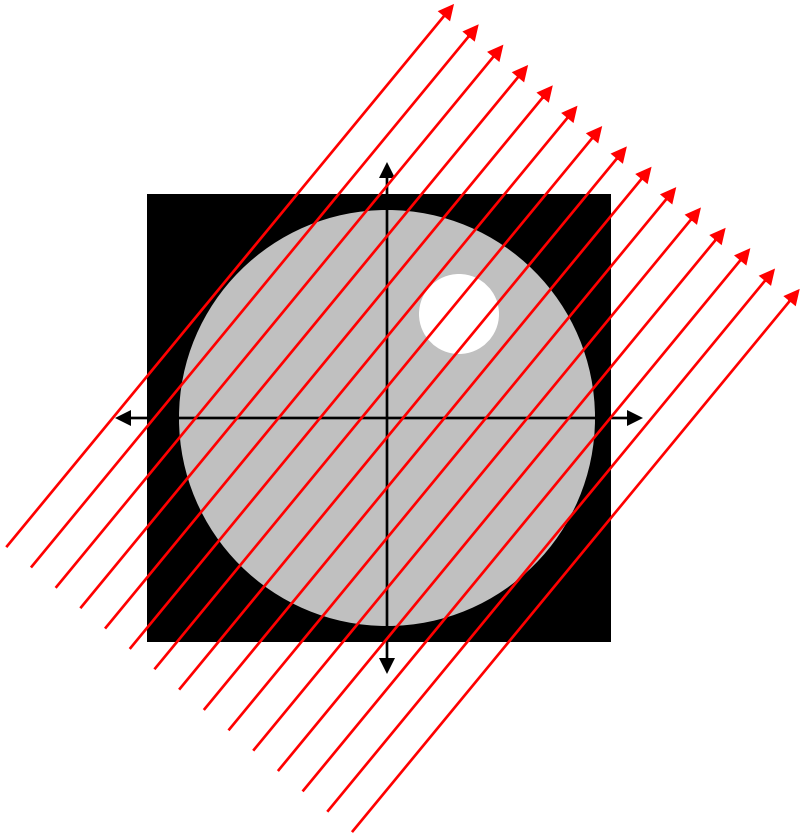

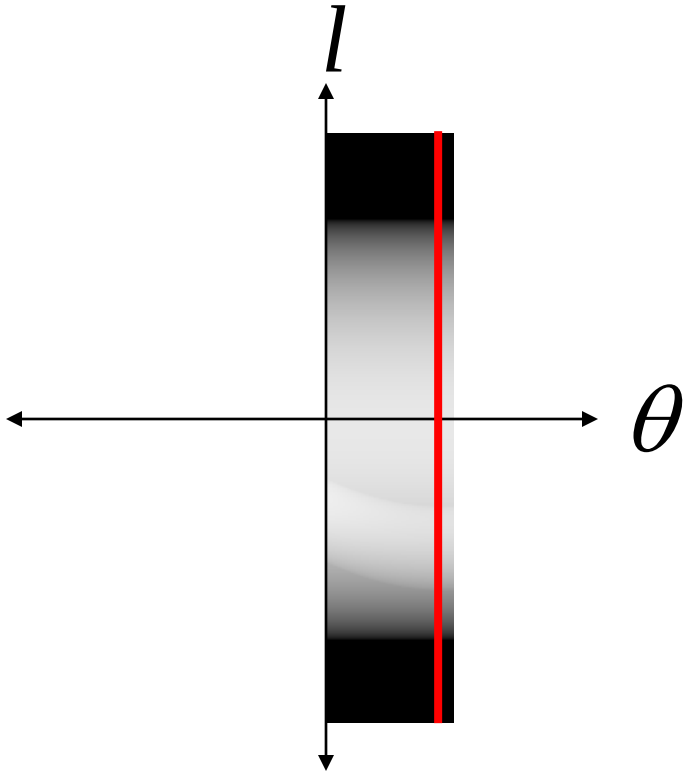

Sinogram

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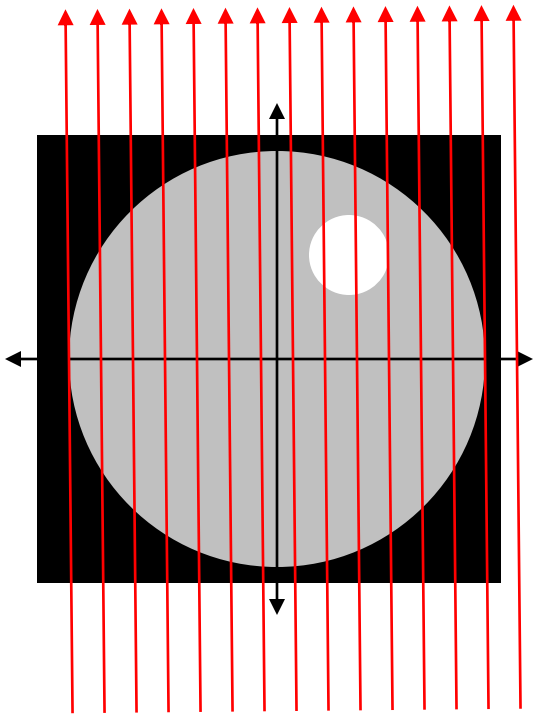

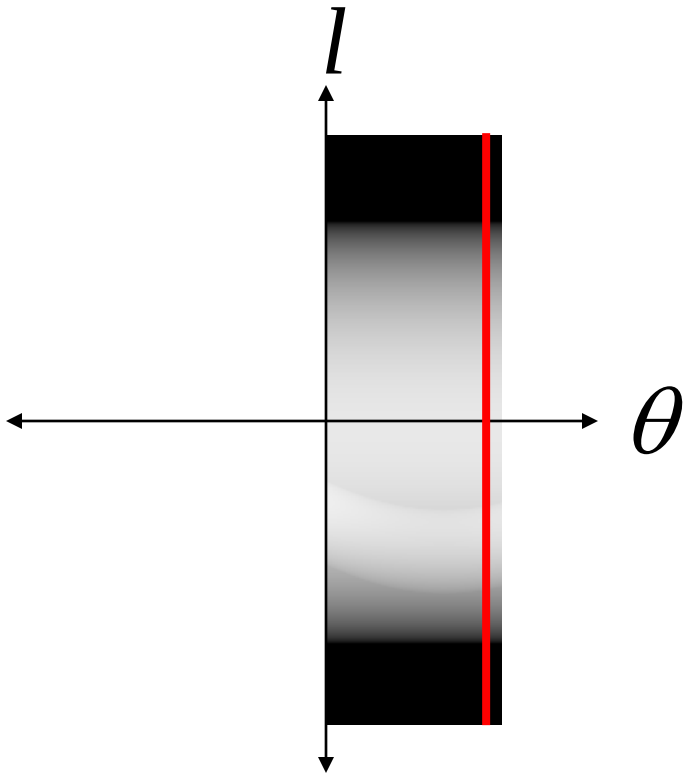

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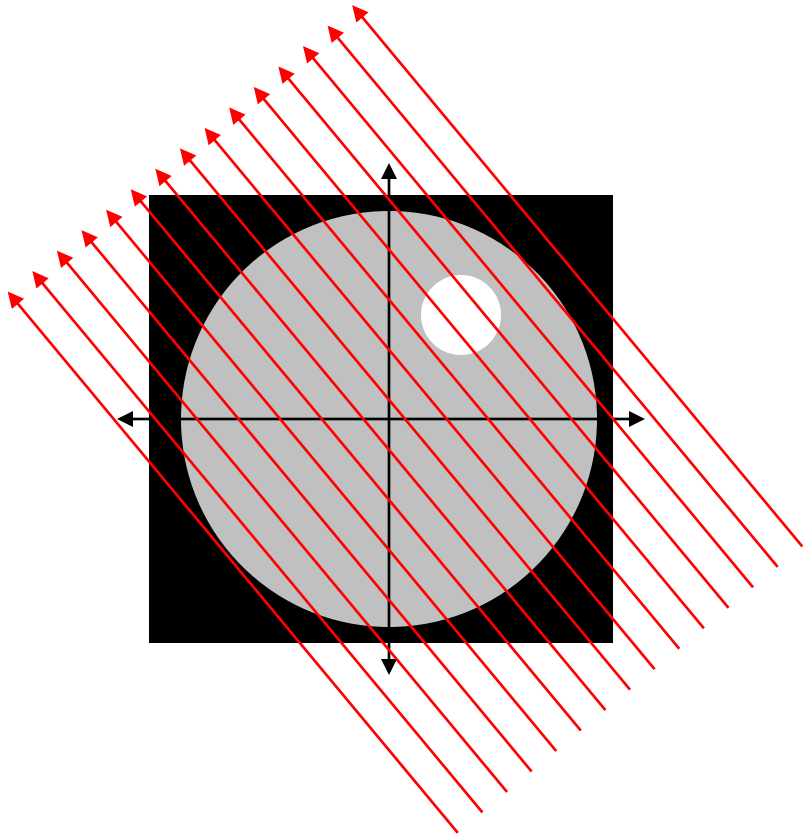

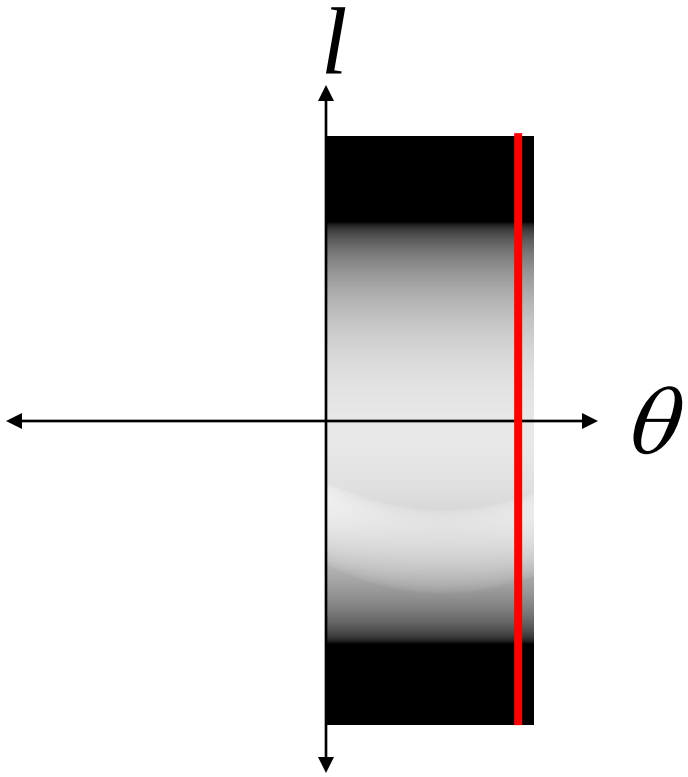

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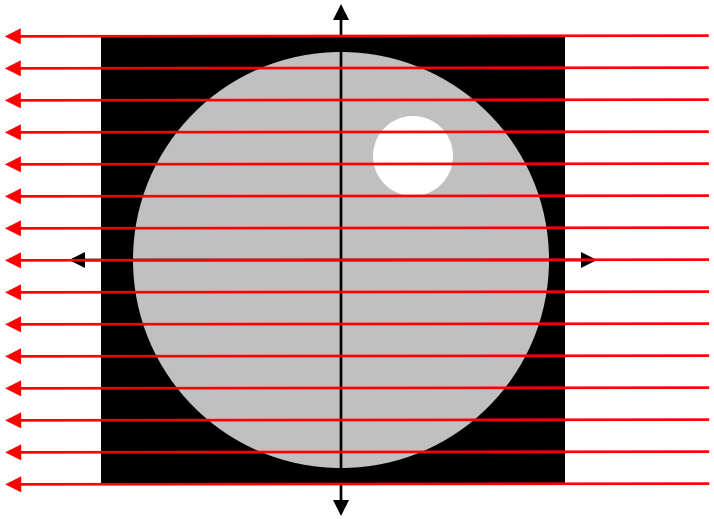

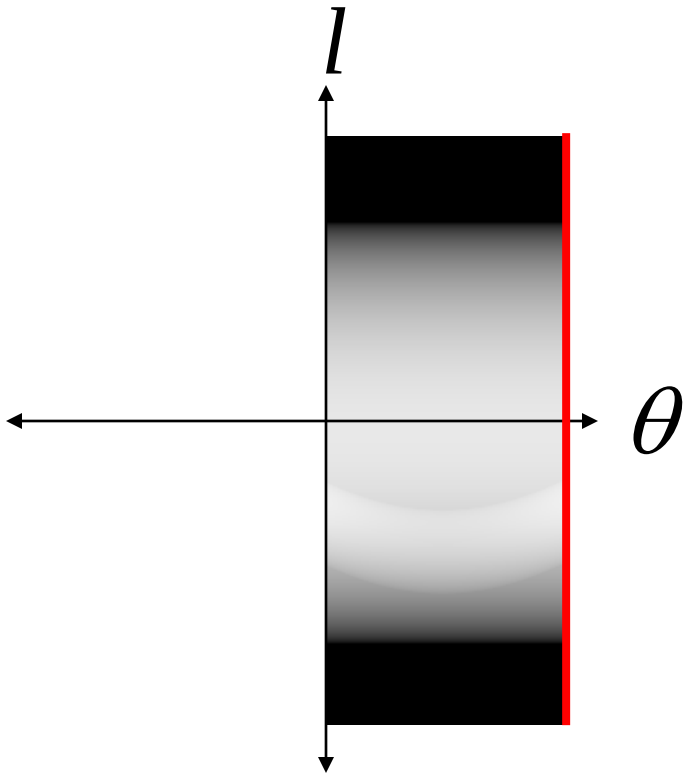

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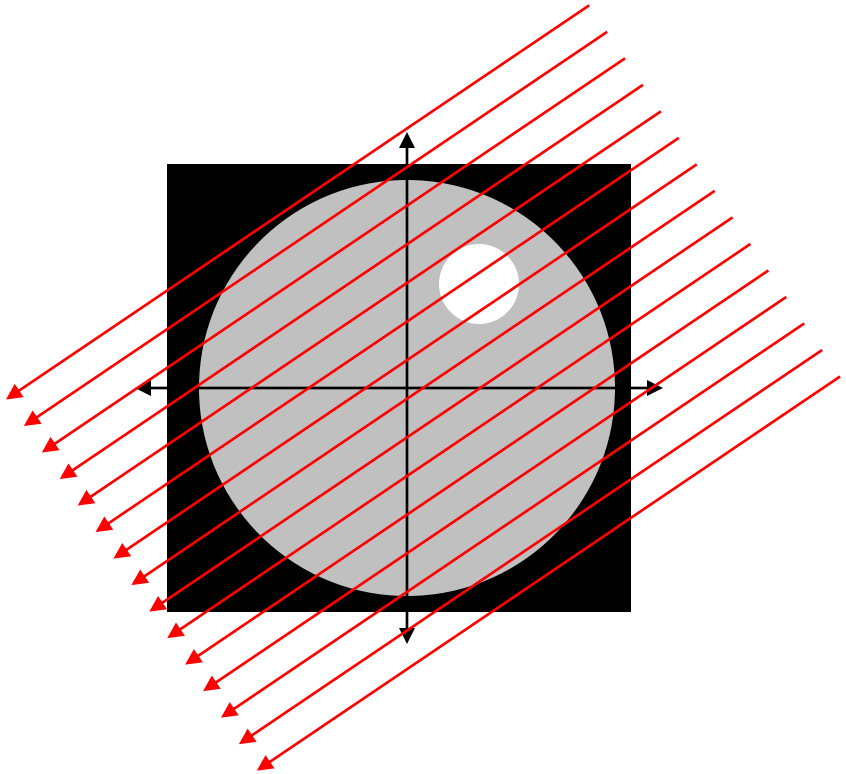

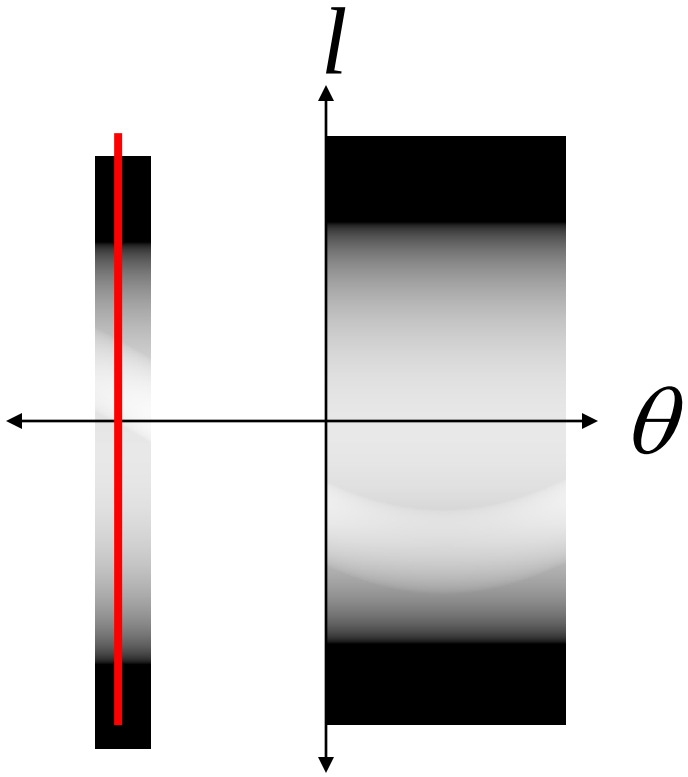

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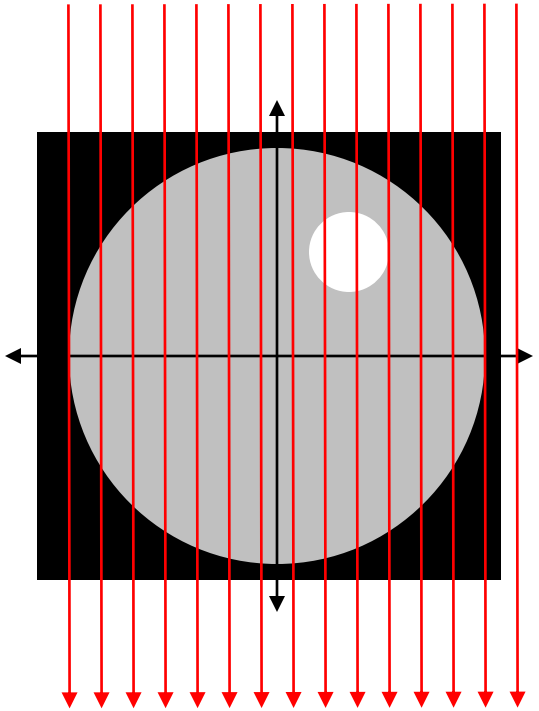

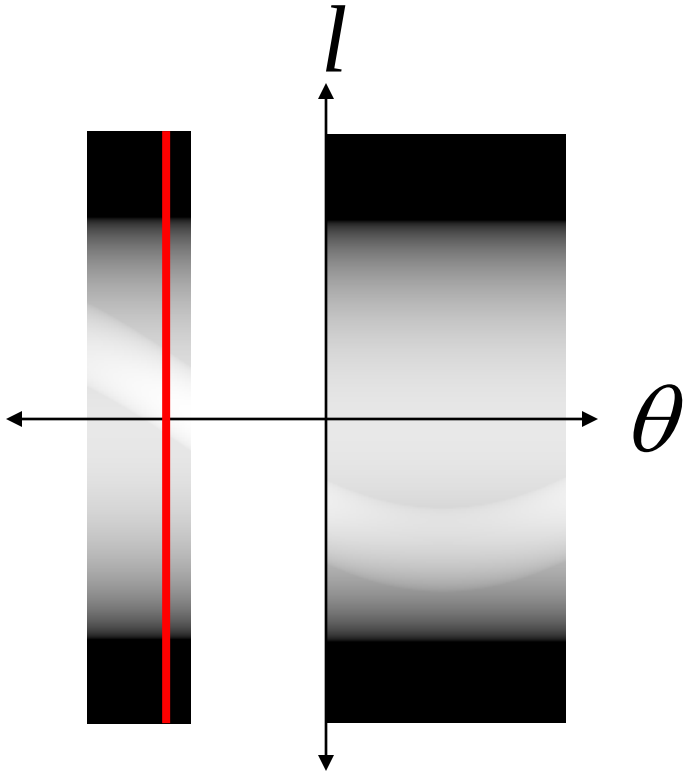

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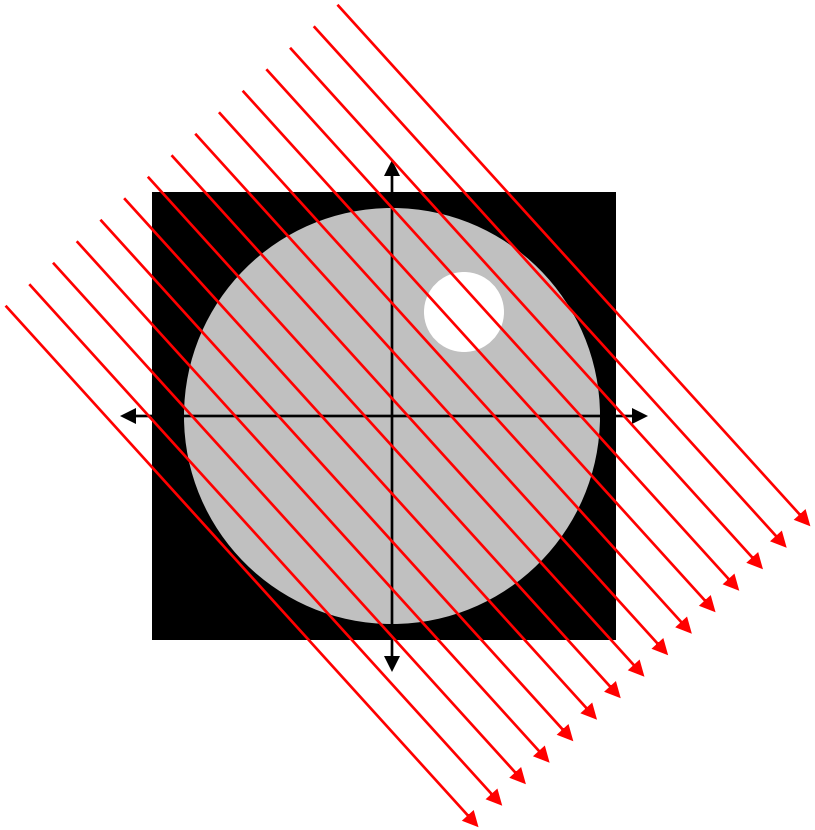

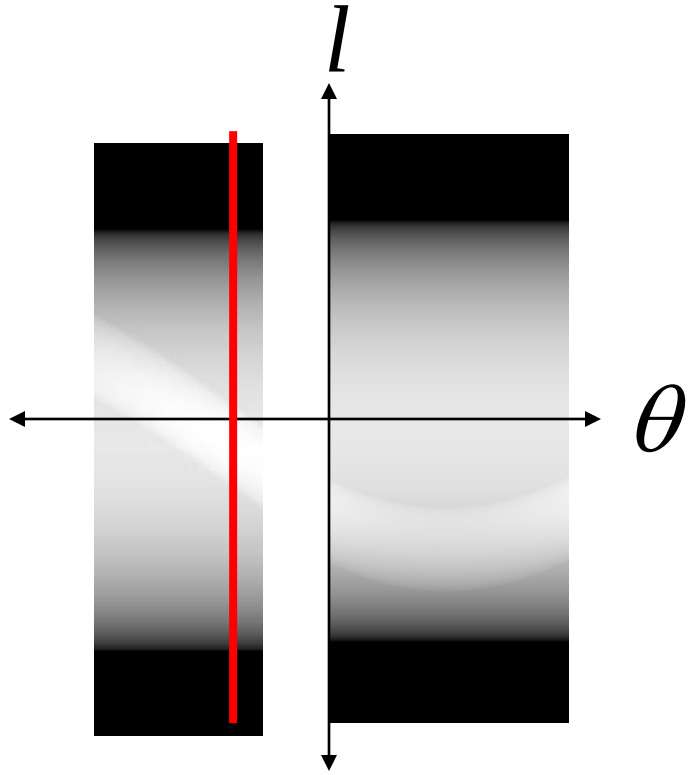

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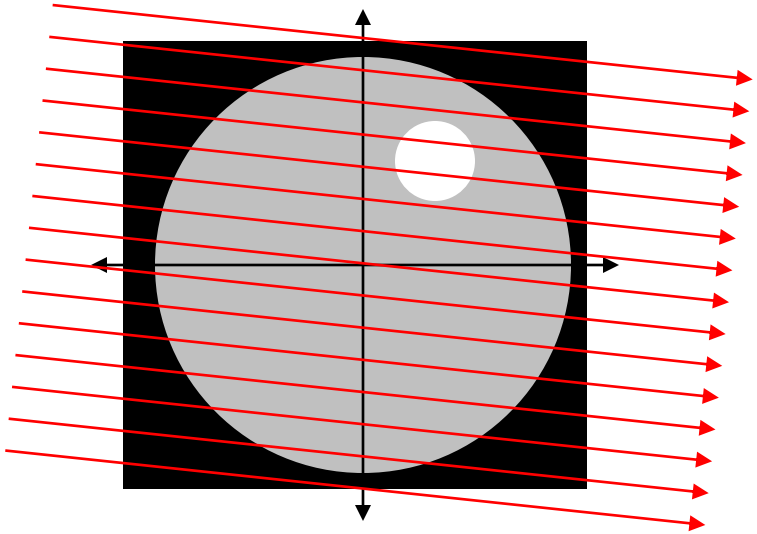
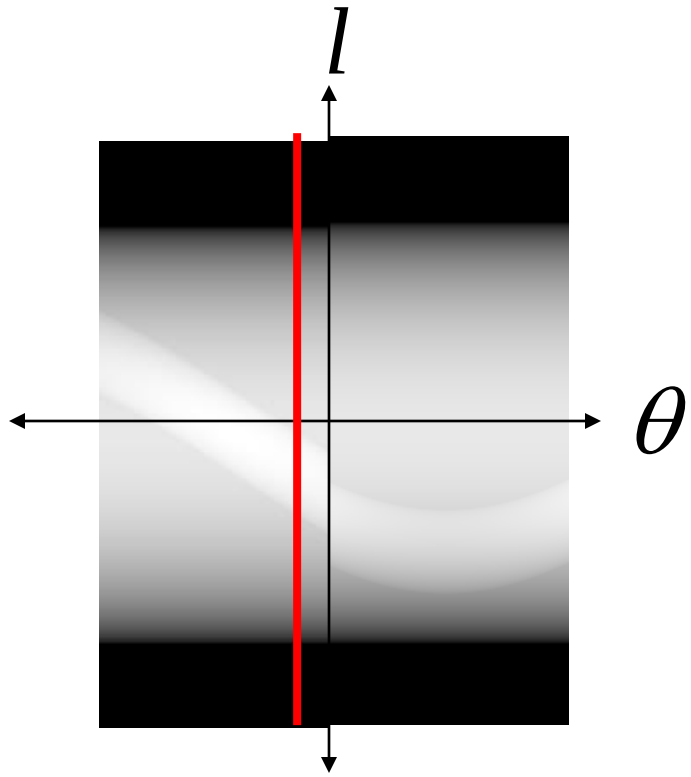




Sinogram

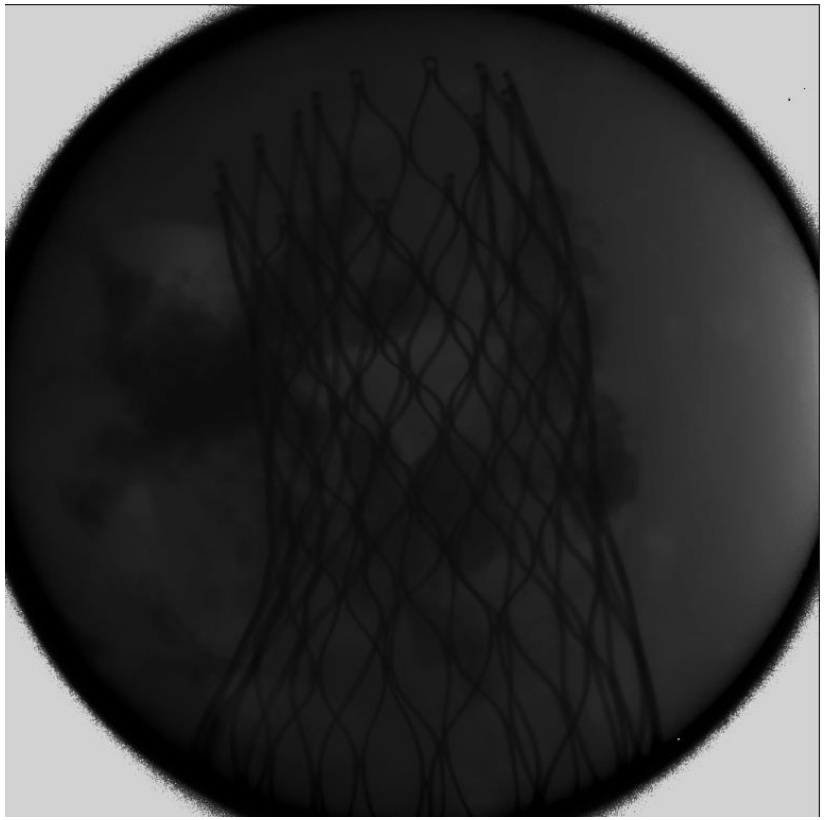
Image courtesy Mark Mirotznik

Experiments

Micro X-Radia CT Scanner at X-Ray Lab

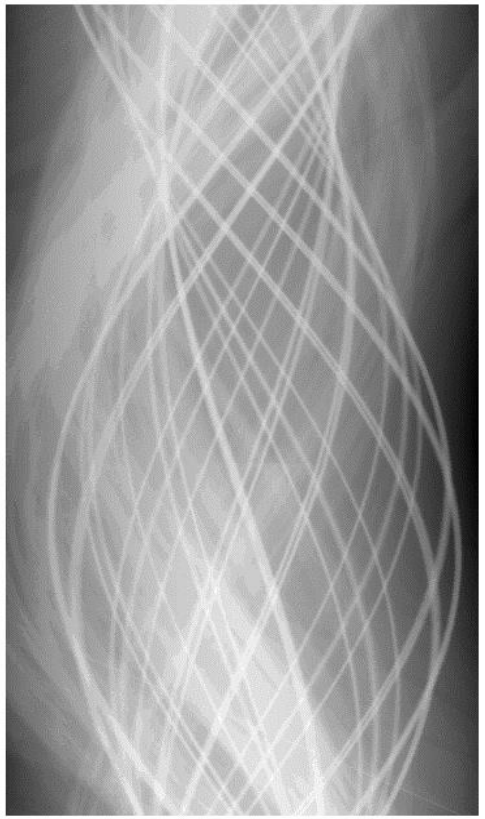
- 1500 projections of 1024*1024 image
- The projections at various resolutions from -96 degrees to +96 degree.
- Data was normalized and sinograms were assembled
- Sparse View Sinograms were constructed by skipping alternate angular projections
- Upsampled and linearly interpolated to be fed to the neural network

Training Data



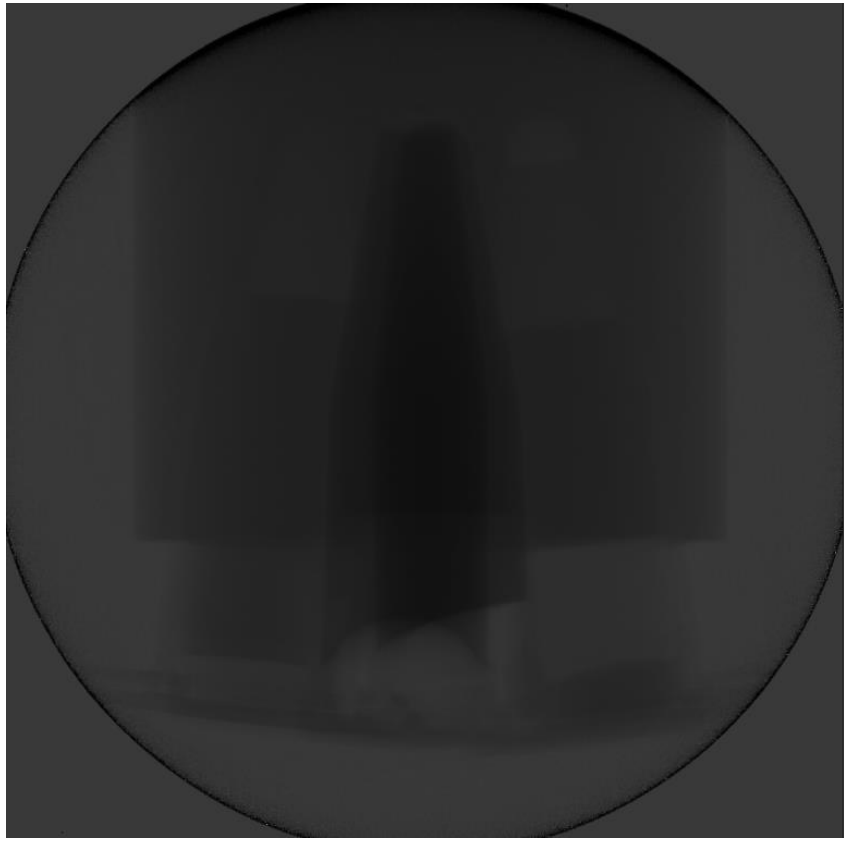
Original Projection

Ground Truth

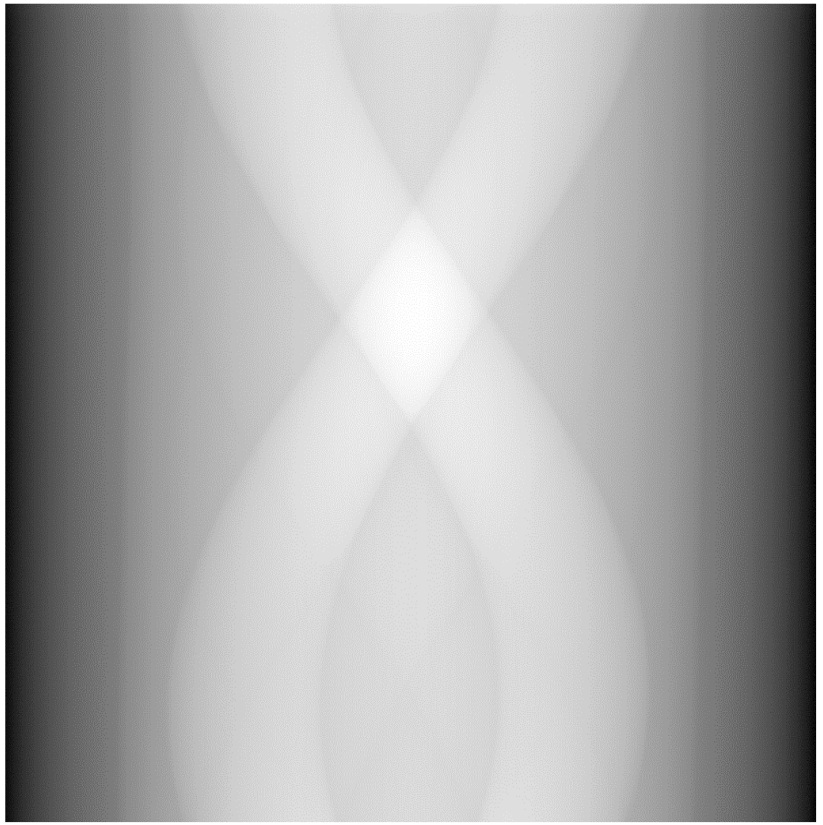


Sparse Up-sampled Interpolated Input

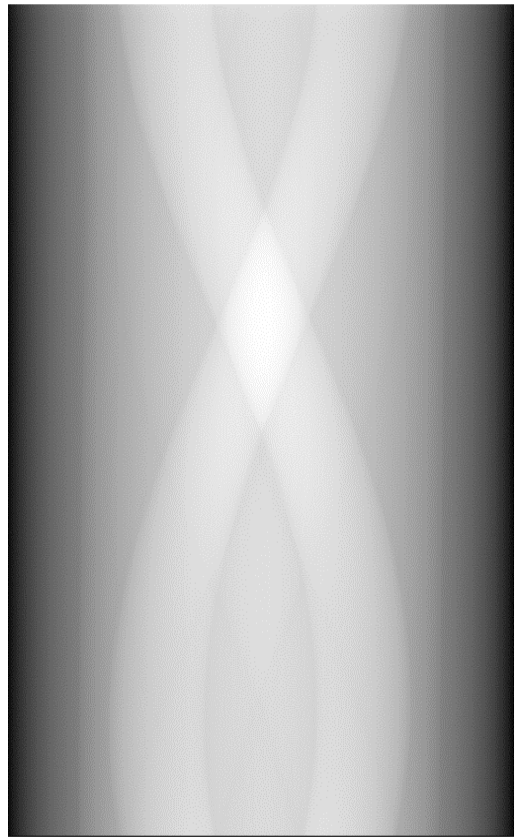
Validation Data



Validation Projection

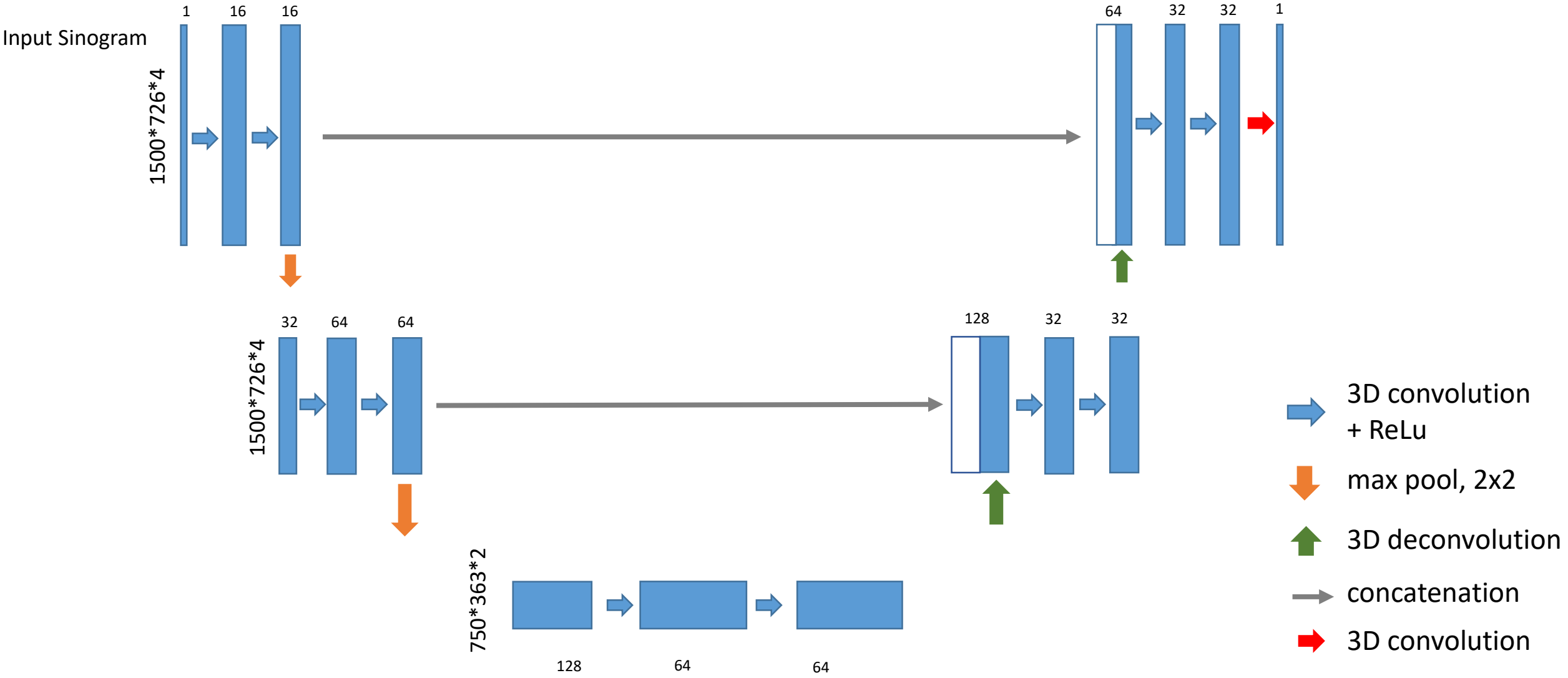


Sparse Sinogram



Linearly Interpolated Sinogram

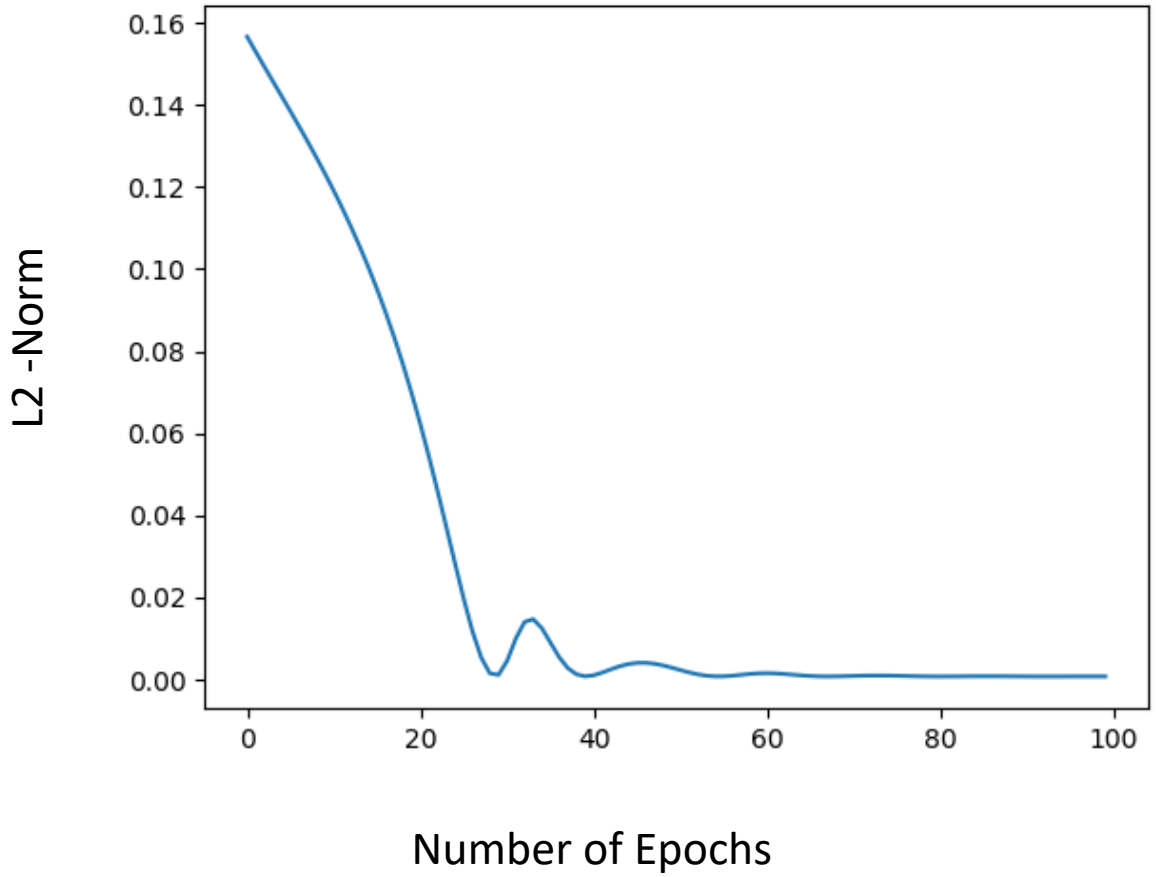
Unet 3D Architecture



Hyperparameters of Neural Network

- Learning rate – 0.0001
- Optimizer- Adam
- Loss Function- L2 –norm, Structural Similarity (SSIM)
- Quality measure- SNR ,RMSE, Correlation coefficient
- Epochs – 50 (optimum)

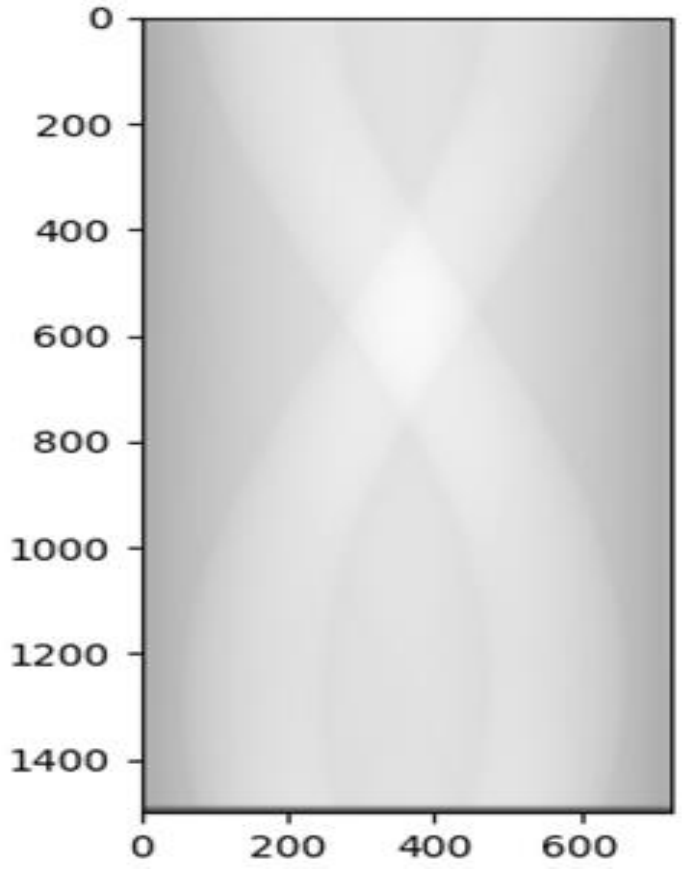
Loss Function



Result and Quality Measures

- RMSE for output Sinogram is 0.326143760756329 1.
- Images are noise free so Correlation coefficient is same as SNR.

$$\begin{bmatrix} 1 & 0.84917601 \\ 0.84917601 & 1 \end{bmatrix}$$



Output Prediction

Next Steps

- Identify optimum configuration and architecture of neural network.
- Run several epochs on the large training set for dedicated time.
- Obtain output by feeding the test dataset.
- Reconstruct the image from sonogram.