COMPUTATIONAL IMAGING

ACTIVITY

06

RADON TRANSFORMS

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SUBMITTED TO:

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Background

Commonly used for medical imaging applications, radon transform represents an image as a bunch of line integrals. At a particular viewing angle, radon transform is essentially the total pixel intensity of a line crossing, that is

$$g(\rho,\theta) = \int\int f(x,y)\delta(xcos\theta + ysin\theta - \rho)dxdy.$$

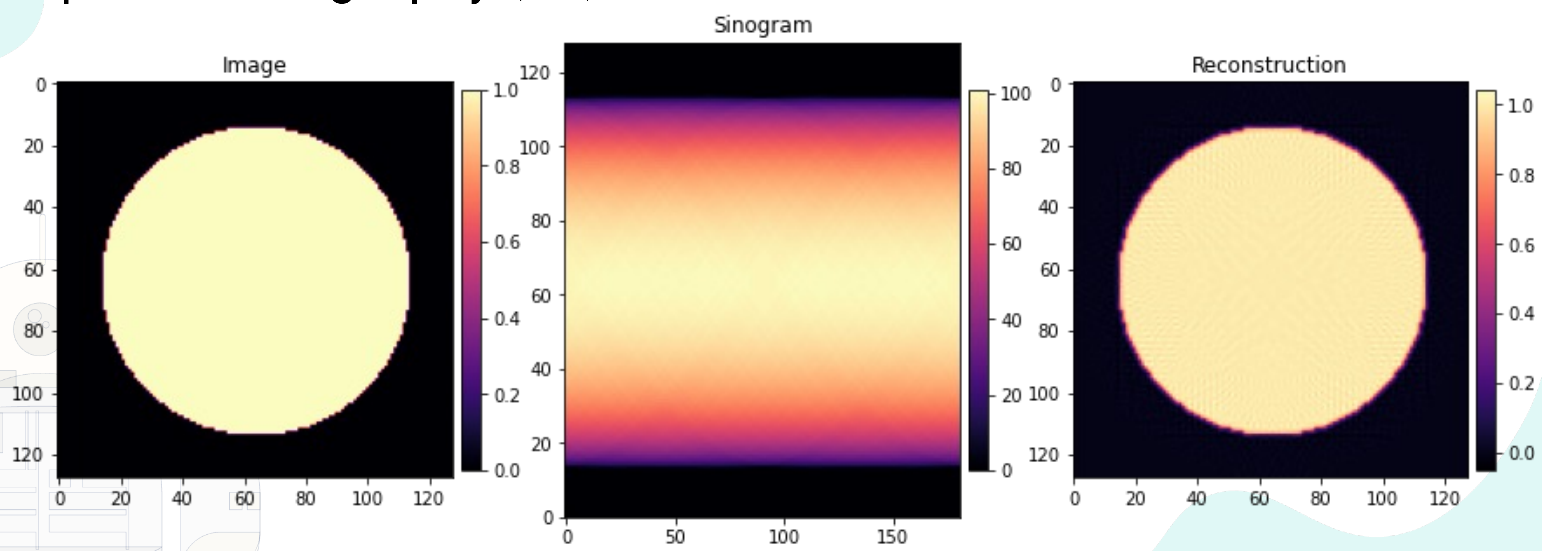
When plotted in the cartesian plane, this is called a sinogram. To recover the original image, the radon transform is back-projected by first converting the polar to cartesian, and then integrated for all the different angles, or essentially,

$$f(x,y) \ = \ \int f\theta(x,y)d\theta\pi 0.$$

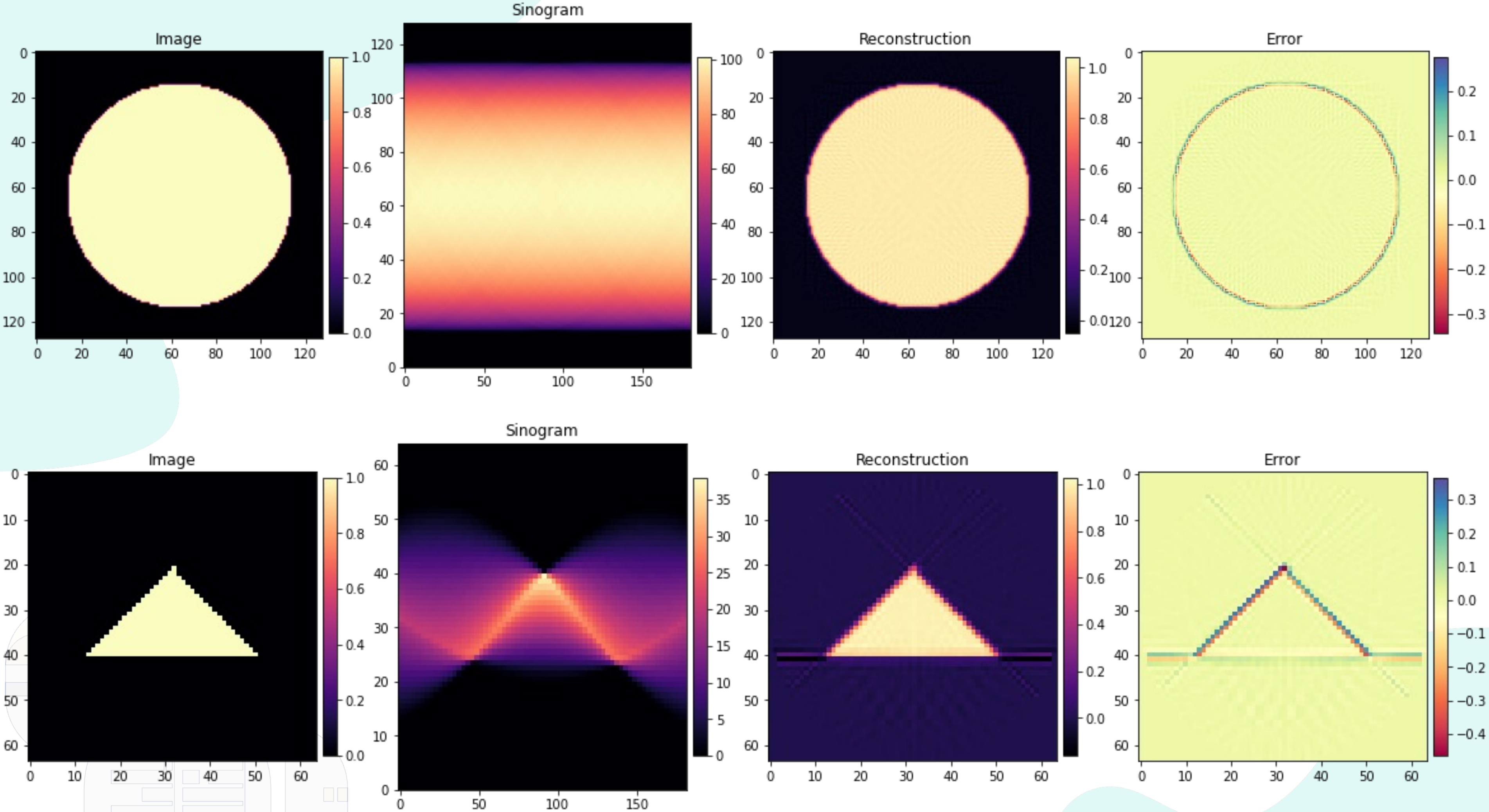
Overview

In this activity, we demonstrate the radon transform and its sinogram behaviour for synthetic shapes with increasing complexity. Transformation in the Radon domain facilitates visualization of structures within the image.

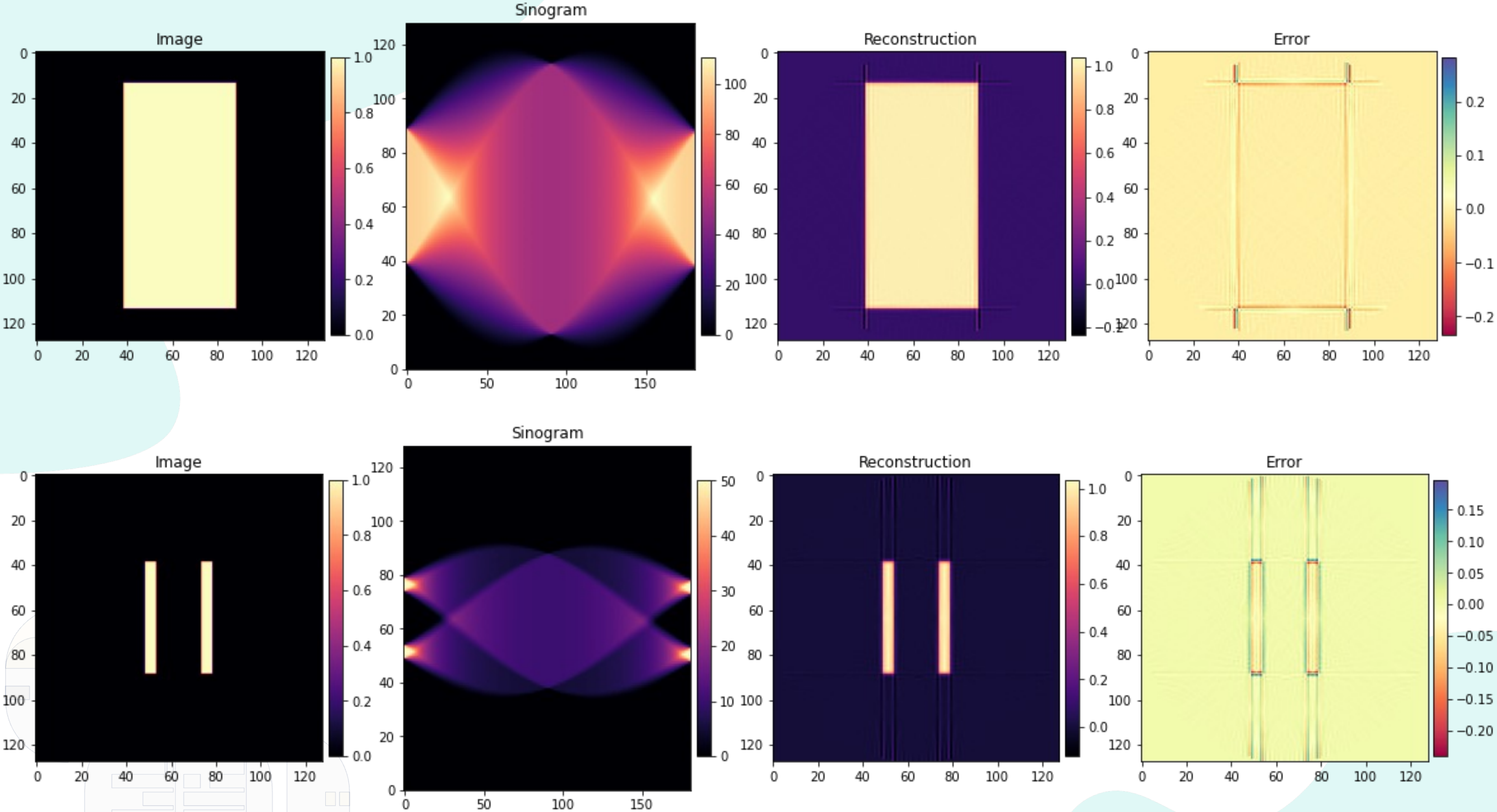
Then, we visualize the reconstruction error after the inverse radon transform is implemented. Lastly, we carried 3D visualization from successive MRI image slices, demonstrating an application in computed tomography (CT).



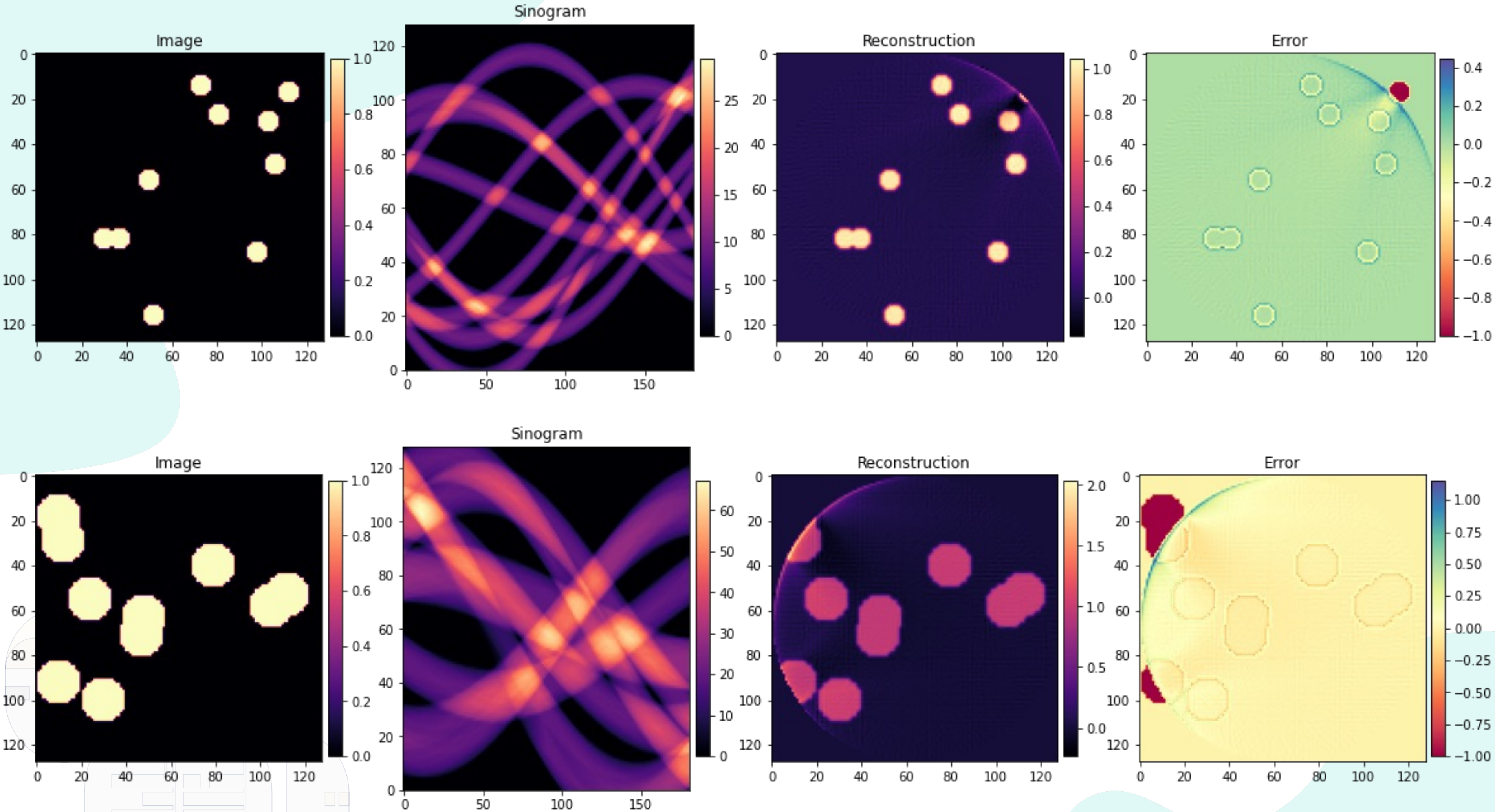
Radon Transform: Basic Shapes



Radon Transform: Basic Shapes



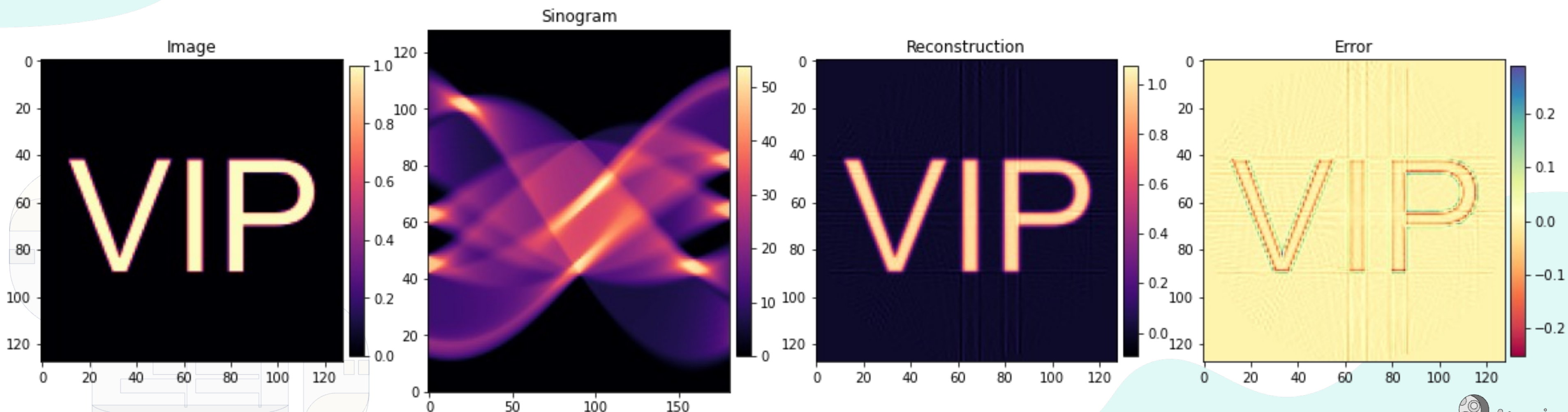
Radon Transform: Many Circles



Discussion

As shown by the results, the x-axis of the sinogram represents the angles at which a line integral is obtained (0 to 180°), while the y-axis represents the spatial extent (128 pixels).

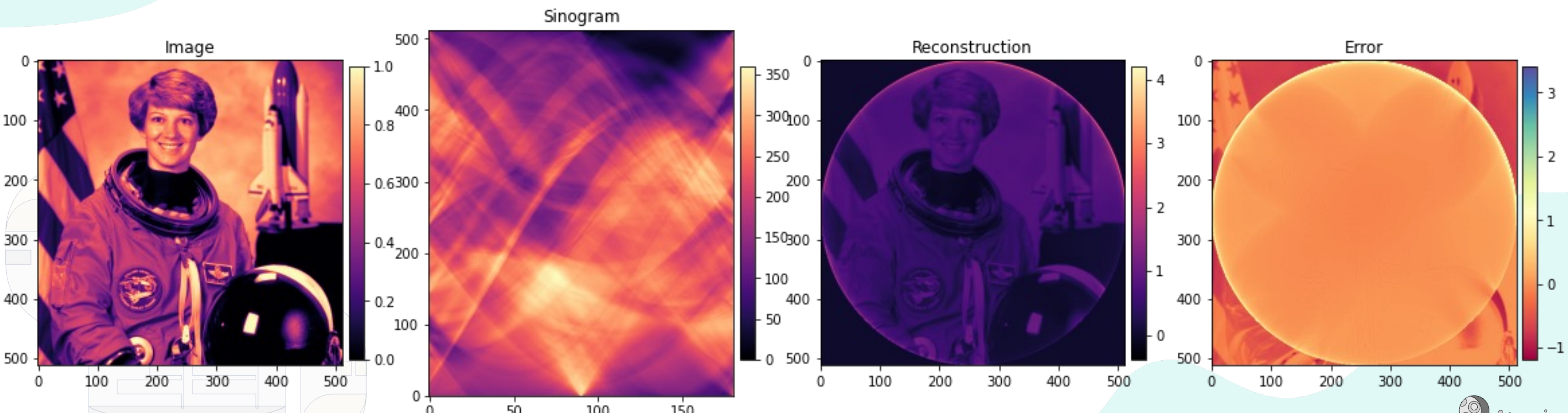
Radon transform's polar projection acquisition is evident on a circular aperture, where its sinogram has regular density. This means it returned equal line integral across all projection angles. Interestingly, the double slit's information is preserved on a sinogram when a projection is done horizontally (at 0° and 180°), where density is lowest upon projection across the slit's width rather than along vertical length.



Discussion

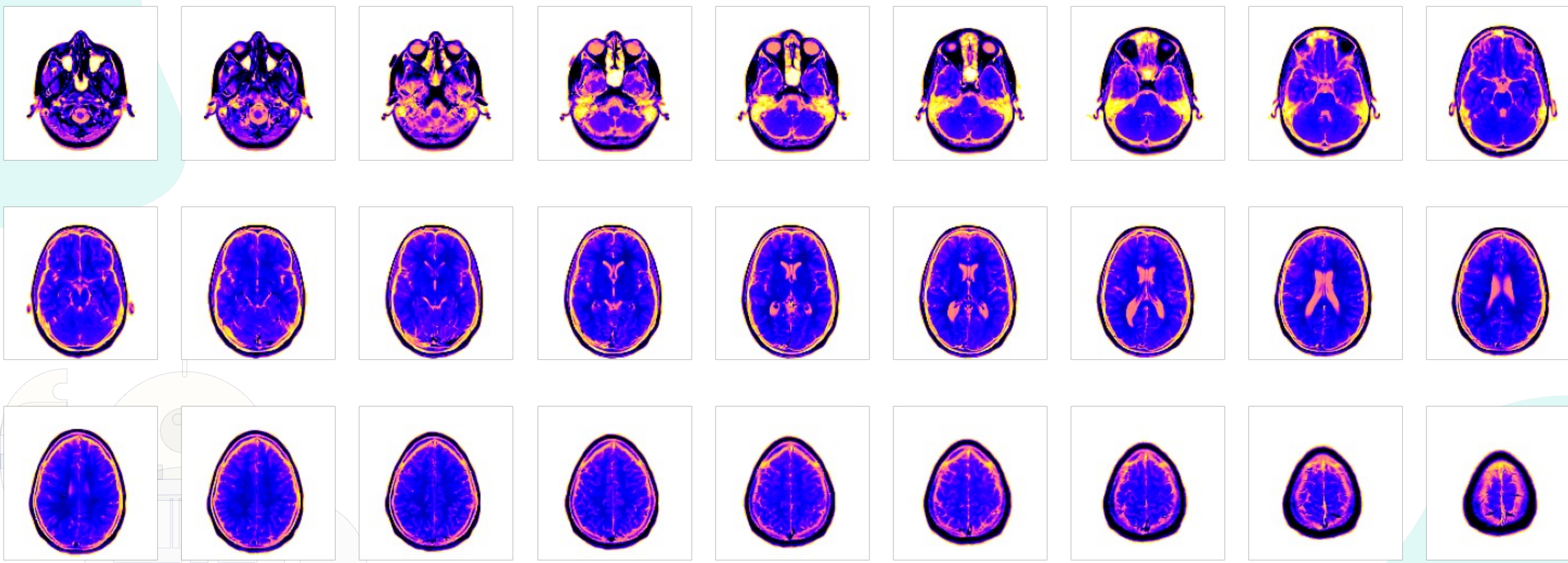
Interestingly, a circular artifact in the recovery was observed on the radon transforms of many circles and on the sample image as shown below. Information beyond this diameter were lost upon reconstruction. This corresponds to the polar nature acquisition of radon transform.

Overall, sinogram represents the radon transform on an image and it shows the embedded features within the object in the form of density. This is widely used in medicine applications, where X-rays are projected from all directions to create sinograms, representing the internal anatomical structures of the human bod.

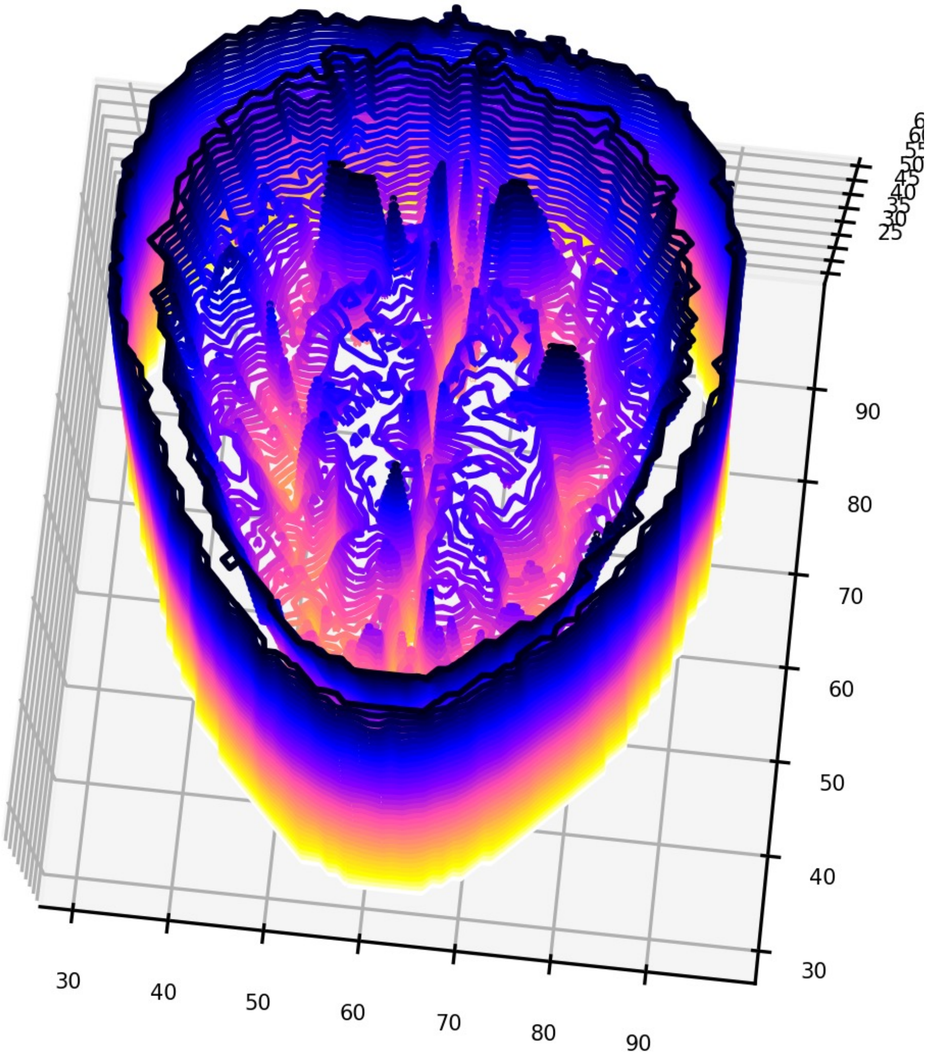


MRI Images

Through sinograms, structures like cross-sectional of the brain are imaged. Shown below are the the sample MRI images recovered using a CT device at successive heights. In this part, we also attempted to visualize these MRI images in 3D.



3D Contours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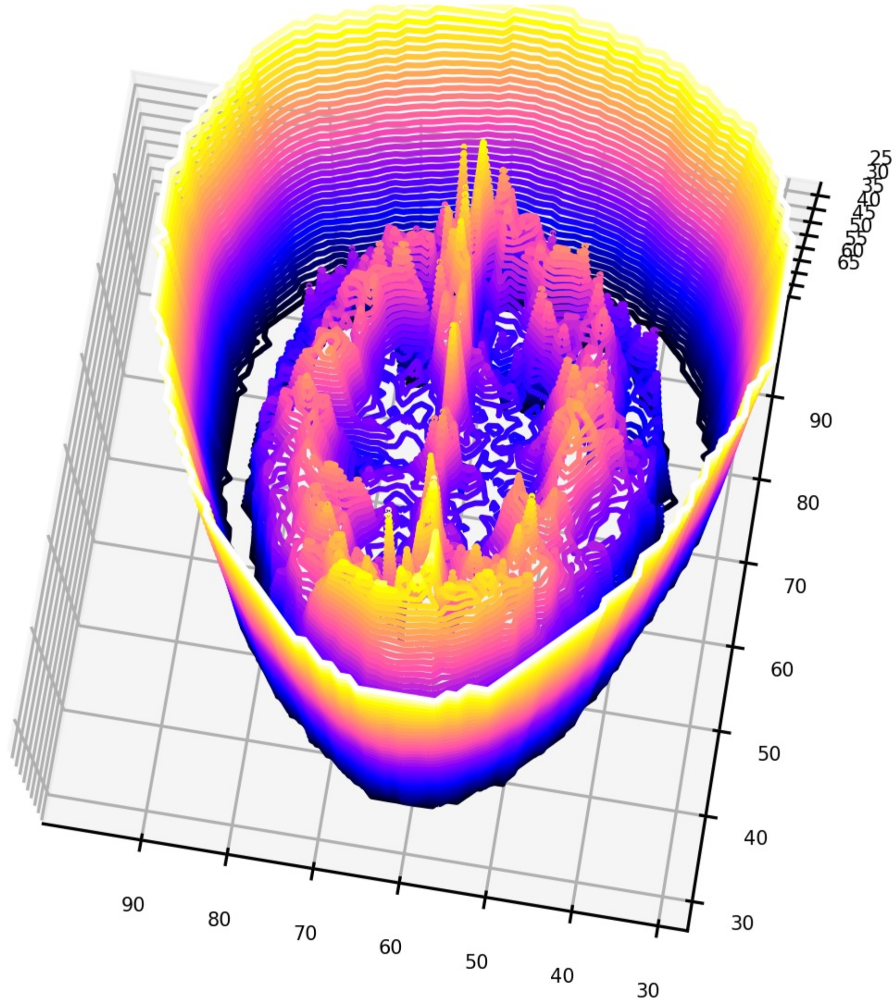
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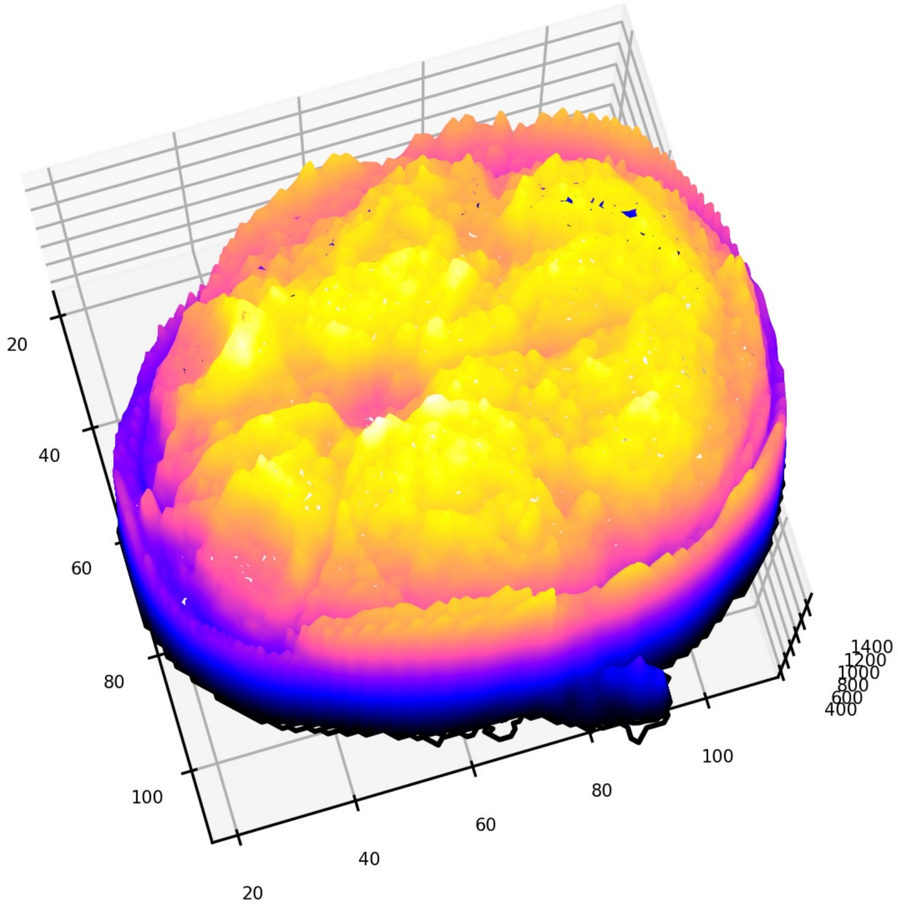
Stacking



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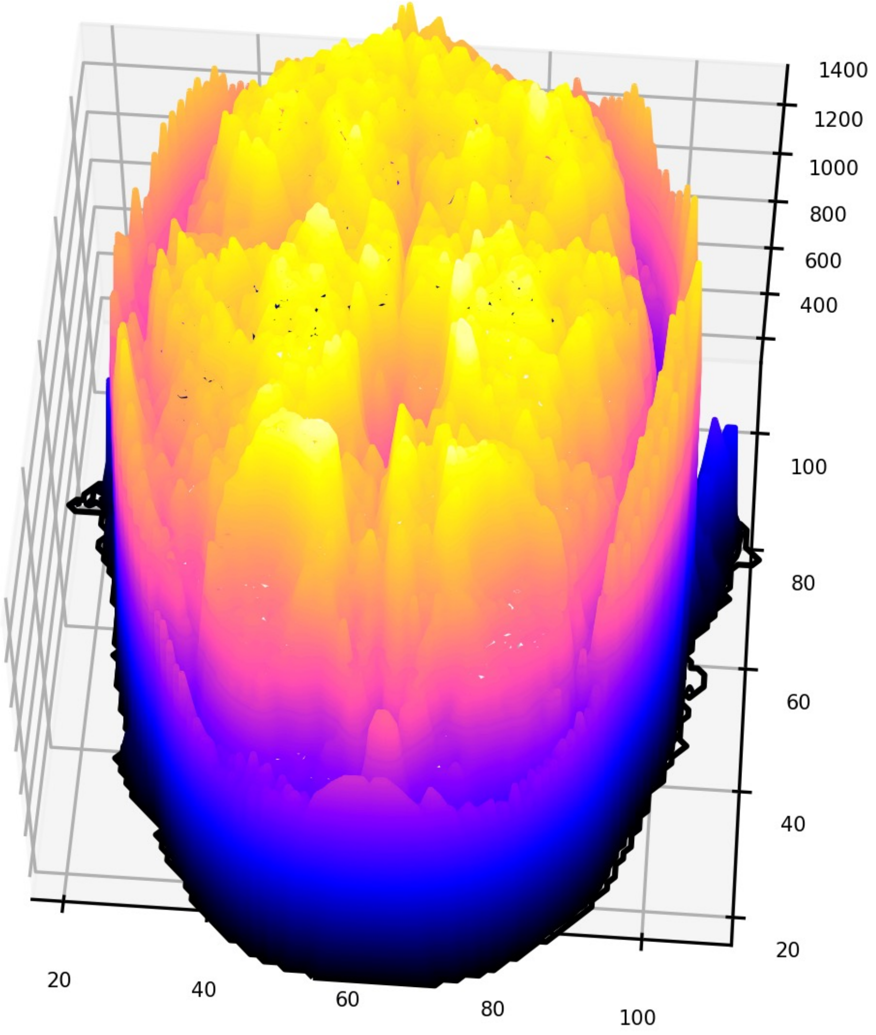

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reflection

I have always wondered how CT scans work and how internal organs such as the brain are images. In this activity, radon transforms yielded sinograms of an image through the principle of projecting at various angles. This was done on synthetic images of increasing complexity. Information along the edges wasn't resolved by the radon transform due to its polar acquisition. I was also able to reconstruct a 3D visualization of successive brain images of MRI scans. I would like to acknowledge Reinier Ramos for helping me process the MRI.mat file and for sharing his code for the corresponding 3D visualization in Python.

With that said, I'd give myself a score of **105/100**

references

- [1] M. Soriano, Physics 305 – The Radon Transform, (2023).
- [2] M. Soriano, Physics 305 – Volume Visualization, (2023).

SOURCE CODE

https://github.com/reneprincipejr/Physics-305/tree/main/Activity%206%20-%20Radon%20Transform