Improving and Applying the Phase Segmentation of X-ray and Neutron Tomography

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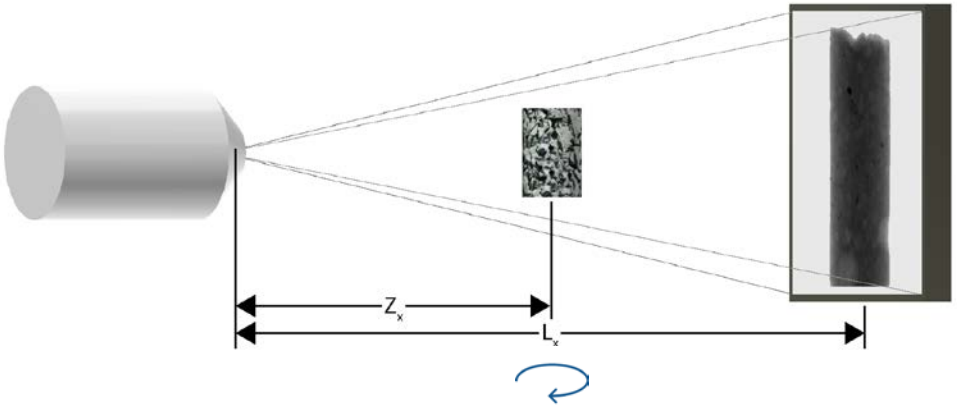
What is Tomography?

- The cross-sectional imaging of an object from many different directions/angles
- Used in medical field

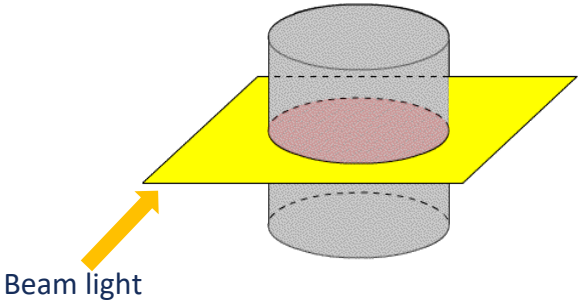
Computerized Tomography (CT) scan

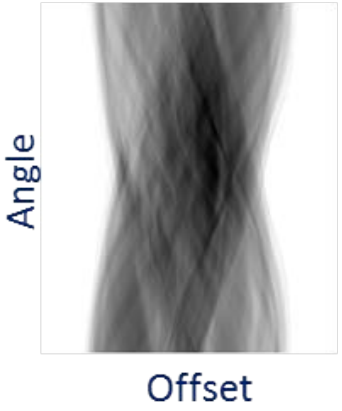


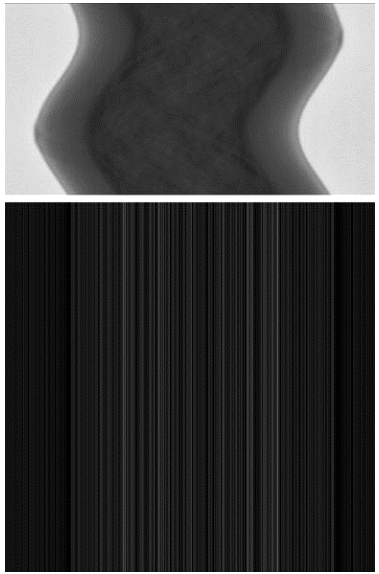
Beam shoots light at rotating sample at the NCNR

Tomographic Imaging

- Reconstructing an image from its projections







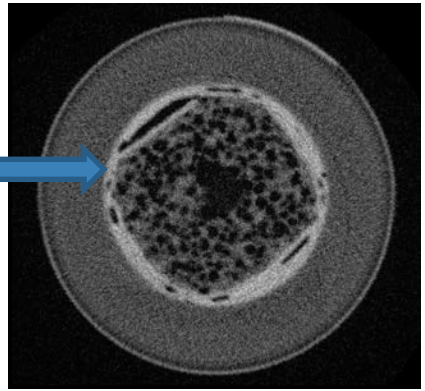
Cross sections → Sinogram → Reconstructed Image

X-ray and Neutron Tomography

- Non-destructive way to determine the internal and external structures of samples

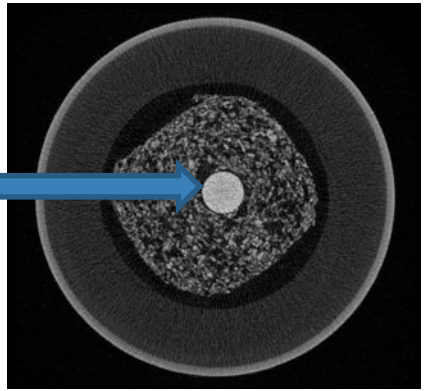
Neutron

Polymer separator clearly seen



X-Ray

Metal rod clearly seen



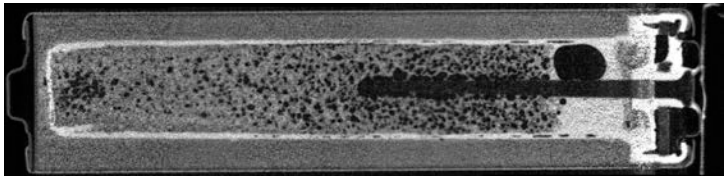
- Neutrons interact with atomic nuclei
- Neutrons can detect lighter materials such as water and organic materials

- X-rays interact with an atom's electron cloud
- X-rays can detect denser materials such as metals

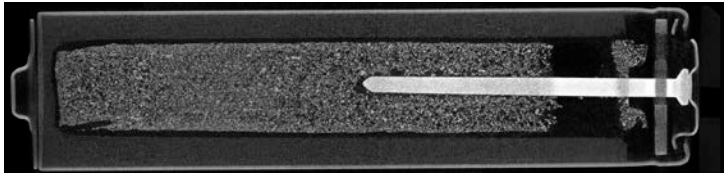
What is Segmentation?

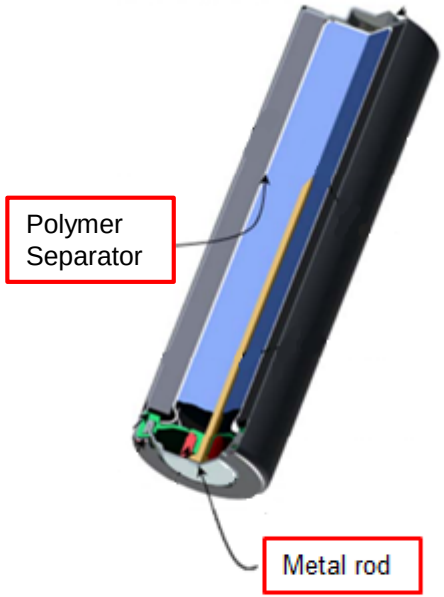
- Process of dividing an image into multiple sections based on certain shared characteristics
- Easier to analyze

Neutron cross-section

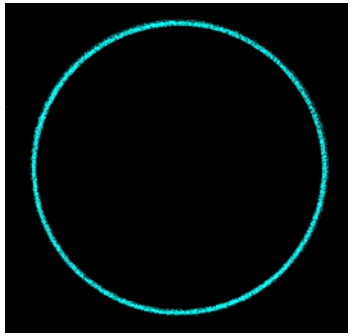


X-ray cross-section

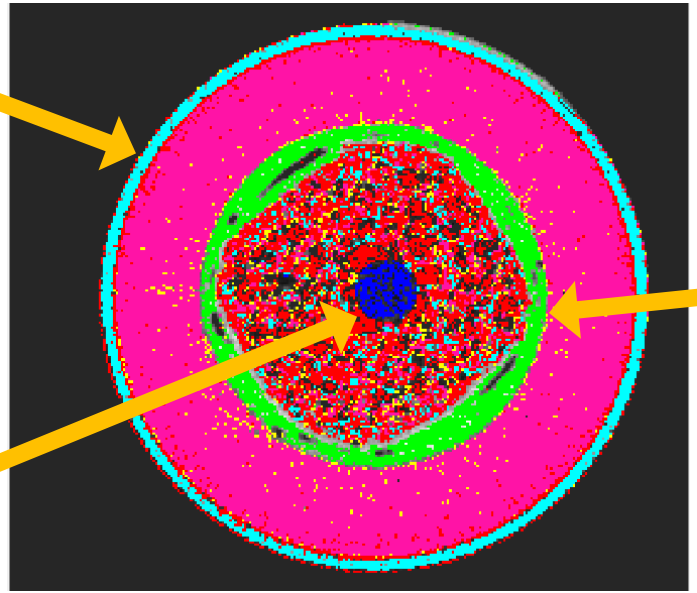




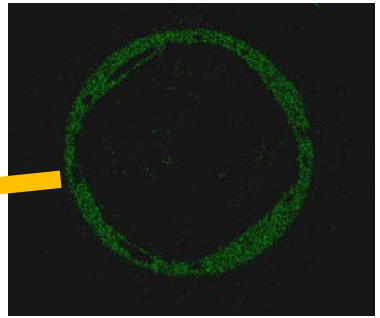
3D view showing segmentation



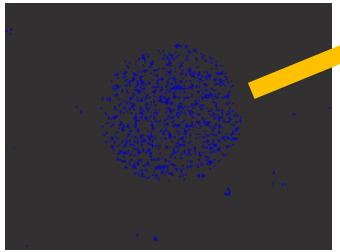
Label



Segmented picture of battery



Polymer separator



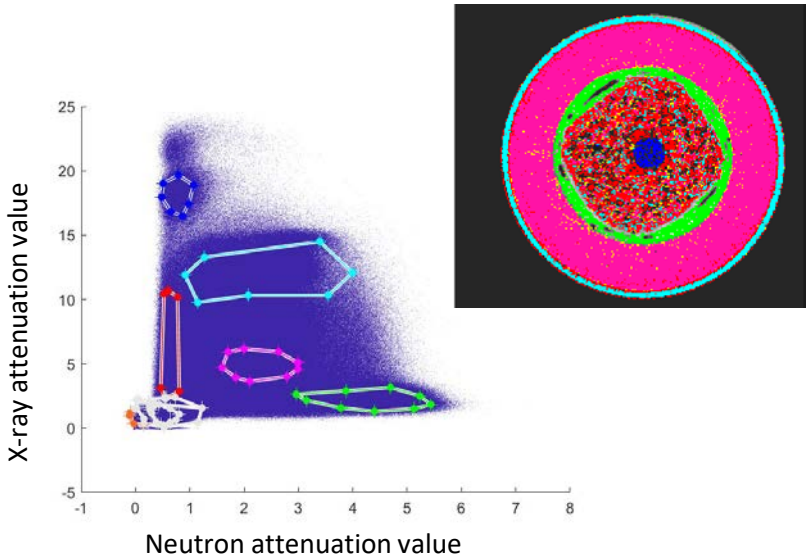
Metal rod

Motivations and Aims

1. Improve phase segmentation program to make more user-friendly
2. Investigate how to extract properties from segmented samples
3. Obtain a 3D model of the internal structure

Dual Histogram

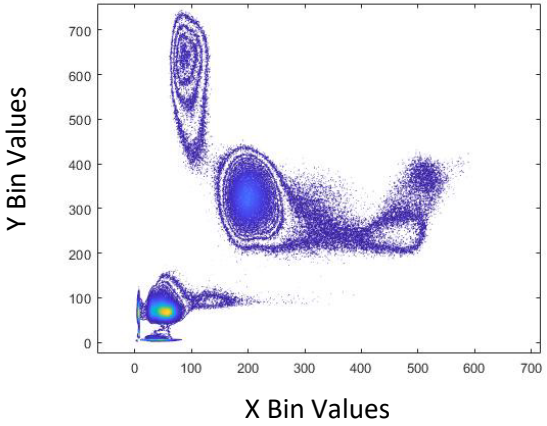
- Polygons drawn are a rough estimate
- Lots of trial and error
- Hand-drawn



Vs.

Contour Plotting

- Easier for user to follow

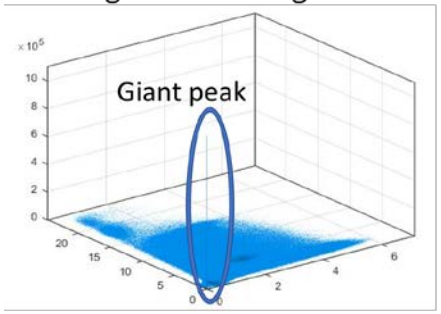



```
histogram2(X,Y,nbins)
```

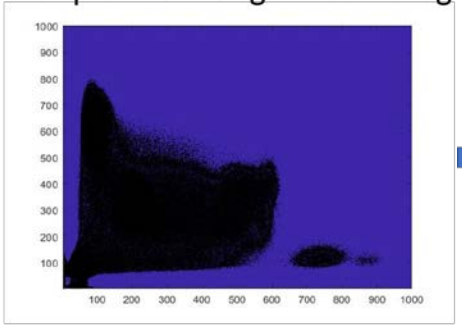
```
contour(X,Y,Z)
```

Optimizing the Contour Plots

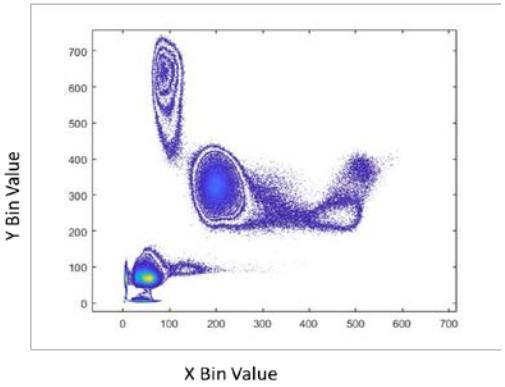
Original 3d histogram



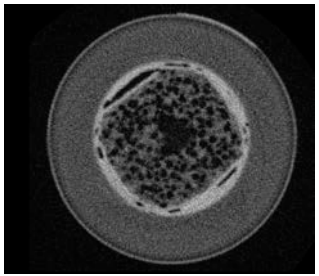
Contour plot from original 3d histogram



Optimized Contour Plot



→ Peak caused from area around sample

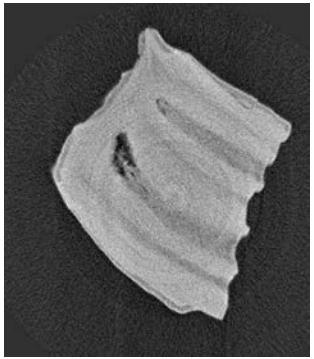


Solutions:

- → Specify specific levels for MATLAB to plot
- → Find maximum and crop out
- → Contourf vs. contour
- → Best color scheme

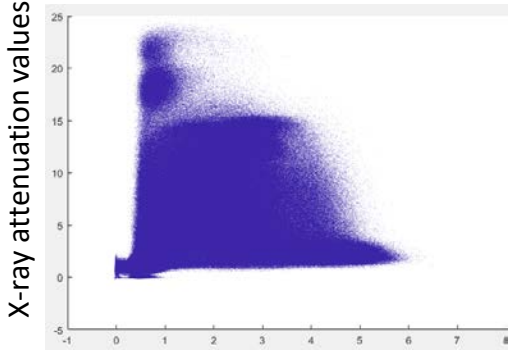
Overlaying the Plots

- Started to align the x and y axes
- Users can use contour plots and histogram data
- Reduces uncertainty in segmentation process

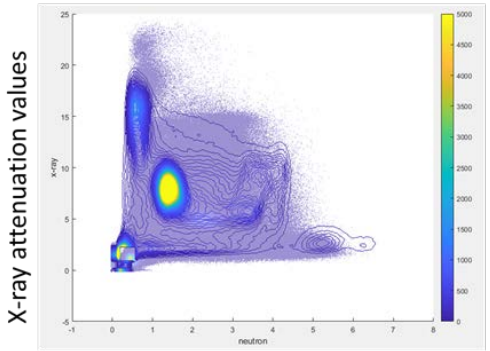


Woolly Mammoth Tooth

Original Dual Histogram

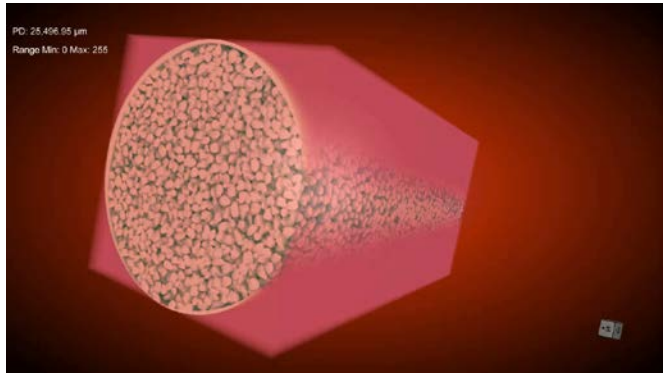


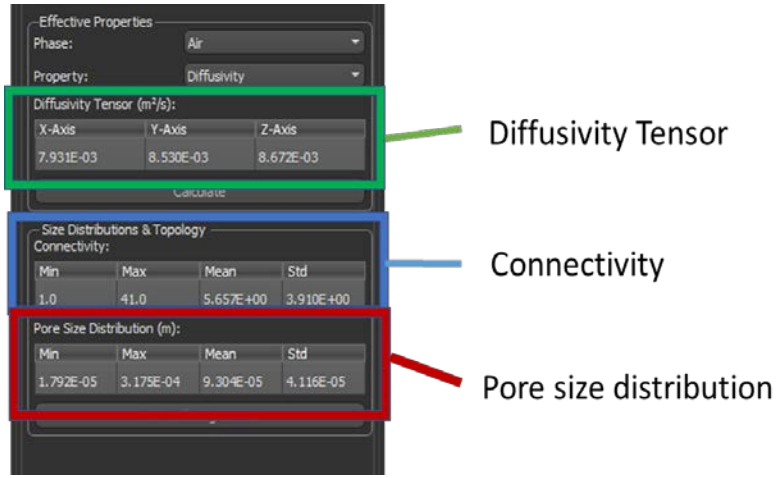
Overlaid Contour Plot and Histogram

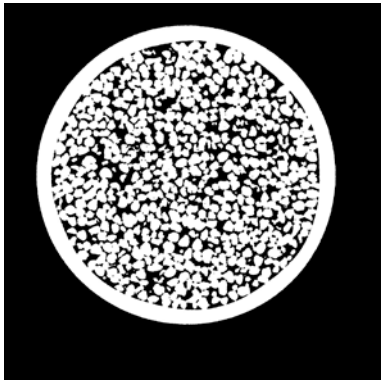


Using Dragonfly

- Defines Regions of Interest (ROIs)
- Learn about different properties

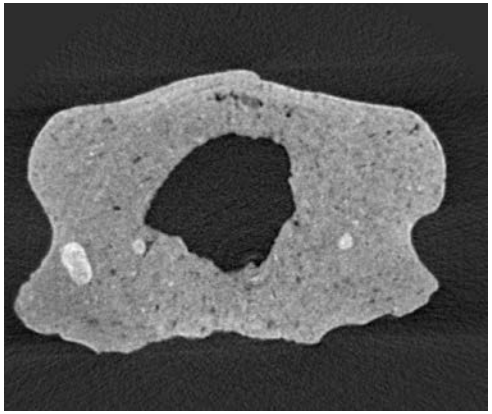


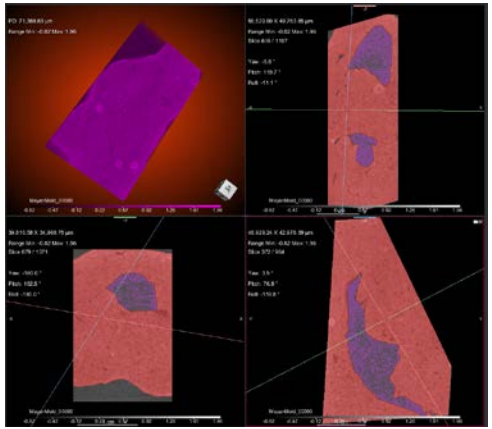




Sand Column

Mayan Artifact





Segment → extract mesh → save as .stl file → 3d printing

Summary

1. Determined that contour plots provide a viable option for improving the process of phase segmentation
2. Extracted various properties from sand column sample
3. Constructed 3D models that aid with understanding of sample

Future work could include machine learning

Acknowledgements

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