Quantitative Analysis for Computed Tomography

MA 390: Research Projects in Industrial Mathematics
MA 490: Research Capstone

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PNNL Background

- US Department of Energy Research Lab
- Located in Ridgeland, WA
- Research in fields of Computational, Physical, Earth, and Environmental Sciences
- Focus on interests of National Security

Image provided by PNNL.

What is Computed Tomography?

- Computed Tomography (CT) is a non-destructive testing method that uses X-ray radiography to analyze internal structure.
- Images are taken from hundreds of angles around the object; data is transformed into a “voxel” format.
- Less precise than Coordinate Measuring Machines (CMM) for external measurement but *significantly* faster

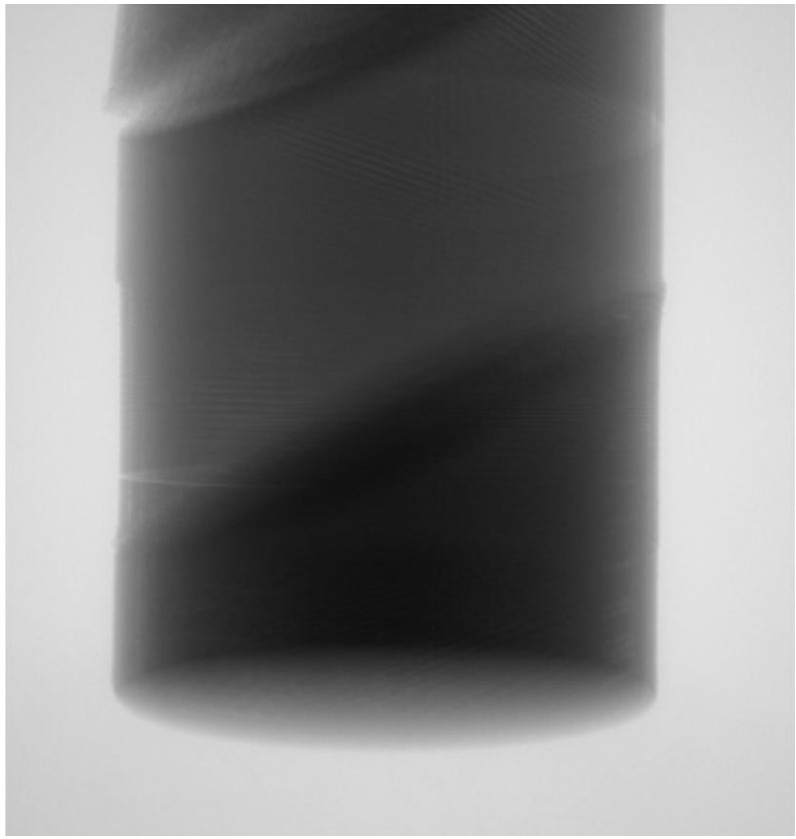


Image provided by PNNL.

Why it matters:

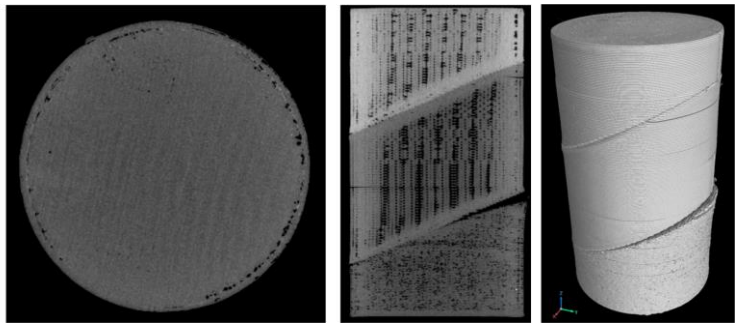
- Helps us to save material and time for the printing process that leaves it with 95% material and 5% air after printing. It also help us to differentiate between the voxels and each of the 3 materials, which is part of the analysis quantities.
- Precise analysis of structure is key for evaluating, calibrating, and improving the technology and its outputs.
- CT scans provide a quick, low-contact, non-destructive method.
- Benefits over CMM (Coordinate Measuring Machine)
  - Less time to complete scans of a given object compared to CMM
  - CT scans are more cost-effective (less expensive per use)
  - Ability to non-invasively probe internal structure (CMMs can only probe outer surfaces)
  - X-ray imaging ensures no damage is done to object during scan

Goals:

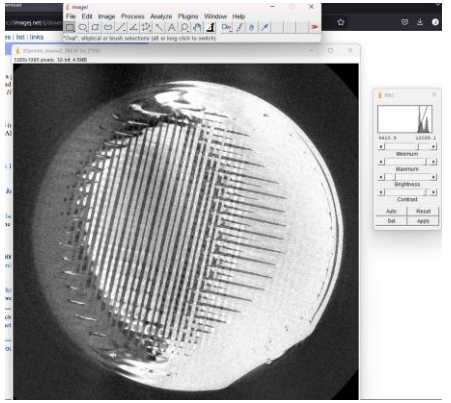
- Establish a knowledge base for the project. (Weeks 1-2)
- Find FOSS libraries for data visualization. (Weeks 1-2)
- Measure from a single slice as a proof of concept. (Weeks 2-3)
- Measure a property across various slices and report value with error bars. (Weeks 3-4)
- Analyze material separation between layers. (TBD)
- Determine the voxel intensities between layers with error bars; segment and label the volume by material. (TBD)

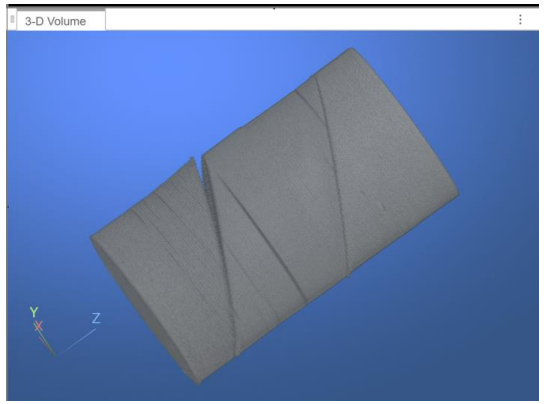
Data Description

- 3D reconstructed object data
- 1789 TIFF files
  - 1085 pixels by 1085 pixels each
  - Can be stacked together to make a 1085 x 1085 x 1789 voxel matrix
- Test Object
  - 3D-printed part
  - Comprised of 3 materials in “top,” “middle,” and “bottom” regions with flat angled boundaries between materials



Images provided by PNNL.





Images generated by the ERAU team.