Boost

Volumetric Ultrasound to Surface Mesh Estimation

A UBC Data Science Club and DarkVision Competition challenge

Donald Nguyen, My Lan Nguyen, Harry Hoang

Boost

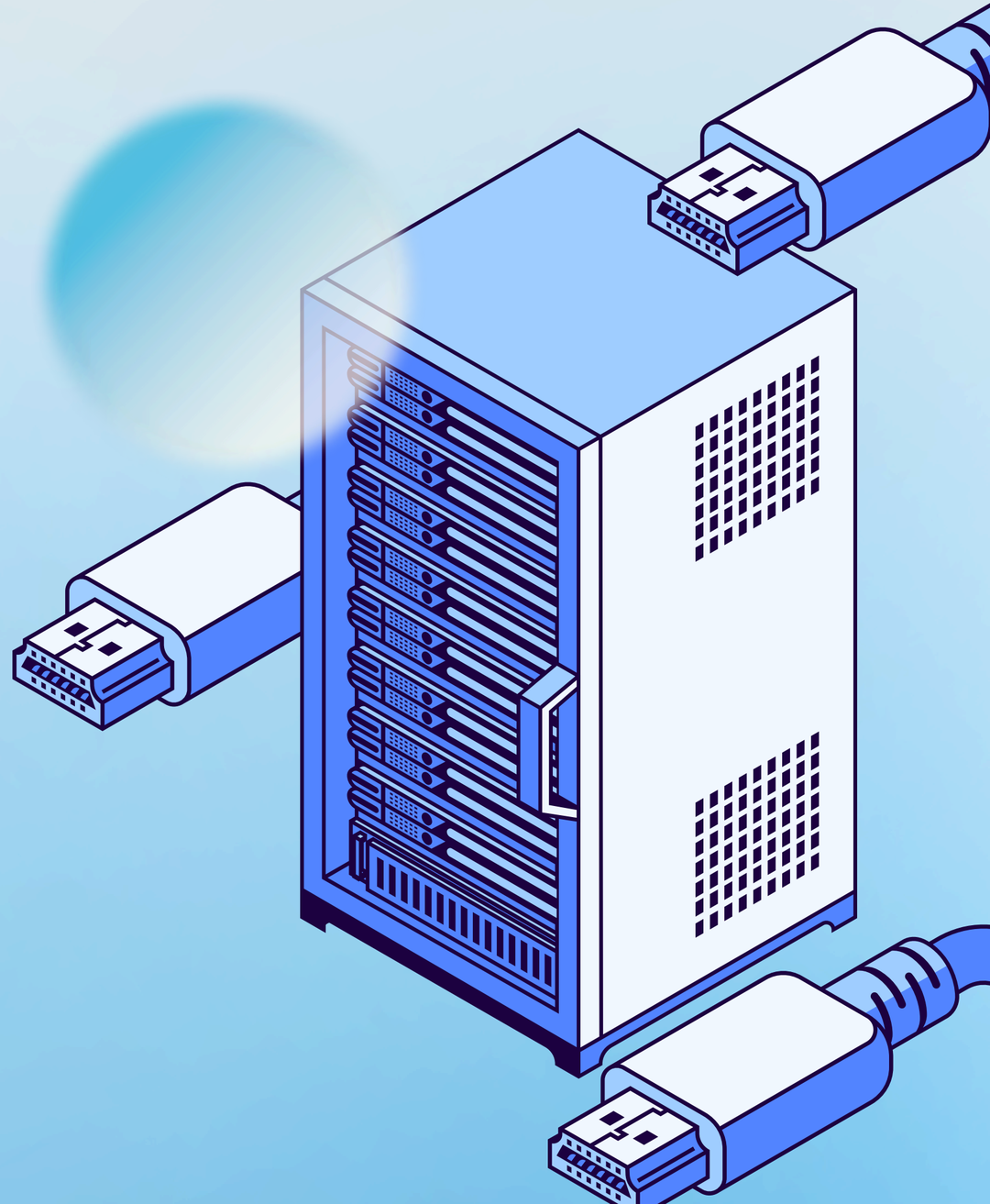
What is Non-Destructive Testing (NDT)?

- Purpose: Ensure the integrity and safety of critical infrastructure like pipes, aircraft, and wind turbines.
- Technique: Uses ultrasonic waves for defect detection and evaluation.
- Importance: Saves billions annually and prevents catastrophic failures.
- Applications: Crack and flaw detection; Early warning for hazardous material degradation.

Boost

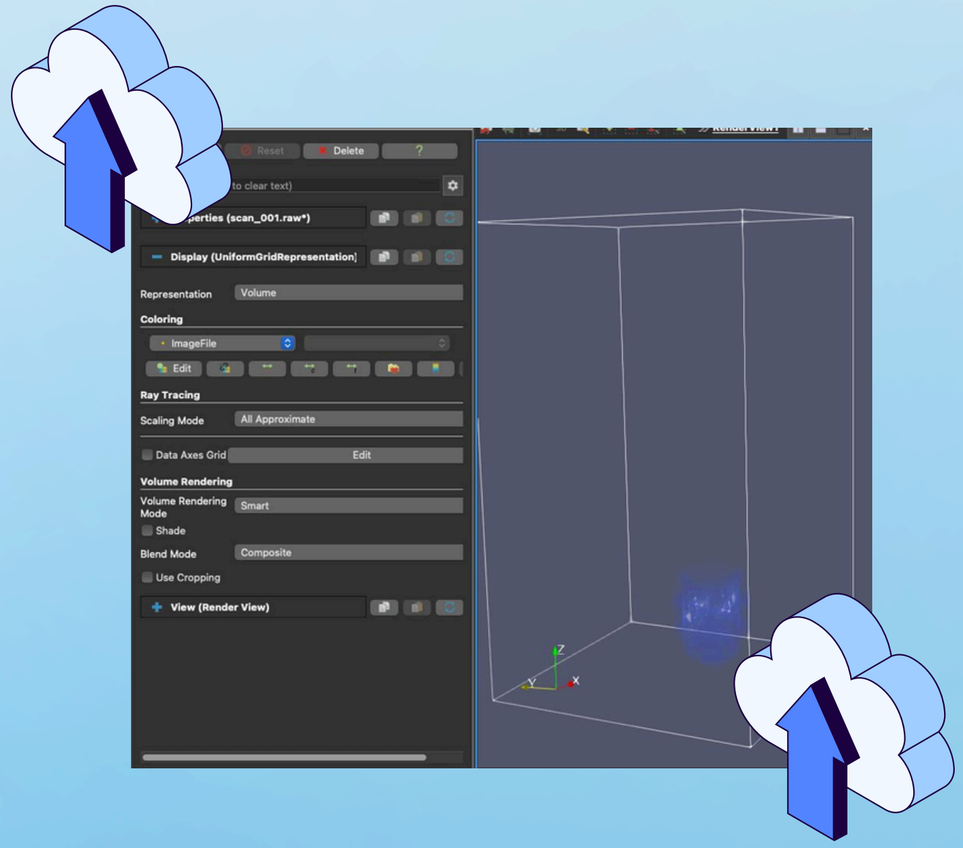
Challenge Overview

- Task: Estimate surface meshes from volumetric ultrasound scans.
- Evaluation Metrics: Chamfer Distance, Hausdorff Distance, and others.
- Focused on deep learning for ultrasound image analysis in industrial NDT.



Studio
Shodwe

Understanding the dataset



Training data

- 89 volumetric scans (.raw format)
- 5 manually cleaned surface meshes (.ply format)

Testing data

- 10 volumetric scans and corresponding surface meshes

Features

- Each scan contains steel pipes, possibly with objects inside the pipes or debris/ dirt at the bottom
- Metadata: 768x768x1280 resolution, origin (0, 0, 0), spacing (0.49479, 0.49479, 0.3125).

Boost

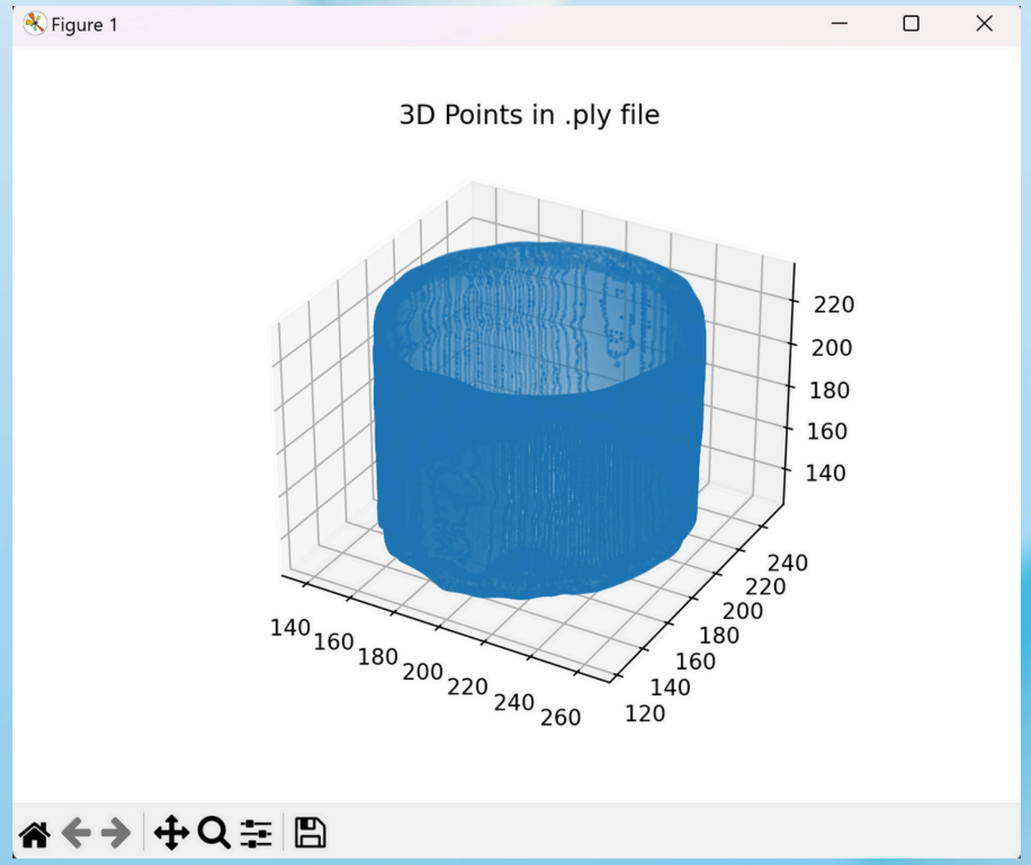
Data Preparation

Volumes

- Normalized values to [0, 1].
- Resized to 128x128x128 for efficiency.
- Added channel dimension for 3D-CNN input.

Meshes

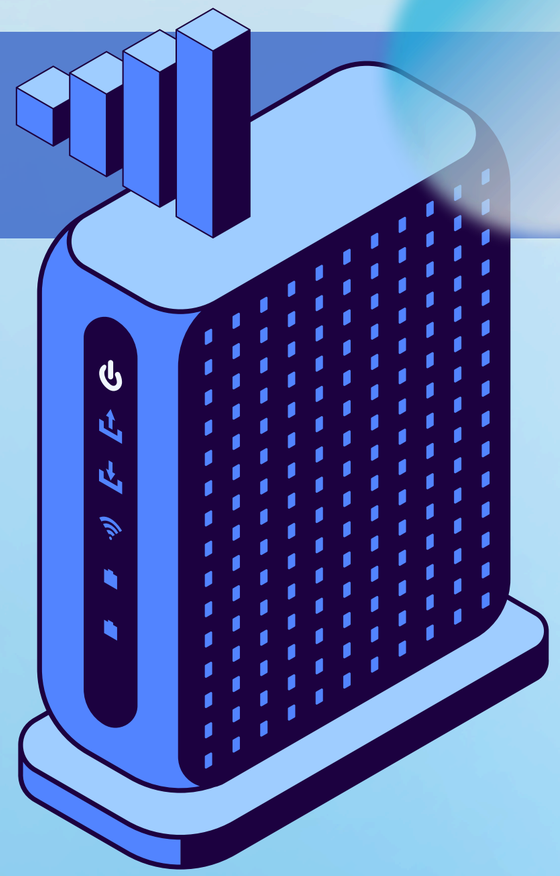
- Centered vertices.
- Normalized to fit within a unit sphere.
- Trimmed/padded to 10,000 vertices for consistency.



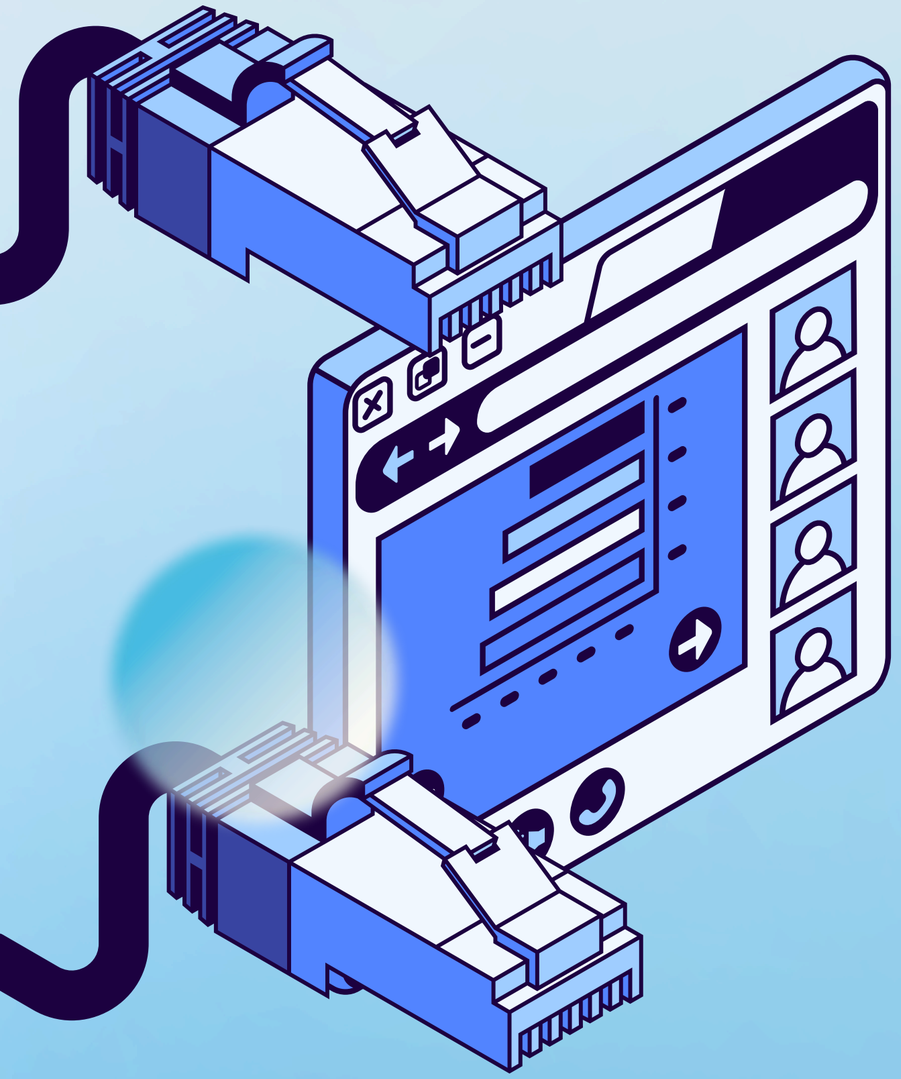
Boost

Volumetric to Mesh Model Architecture

- Backbone: 3D Convolutional Neural Network (3D-CNN)
- Head: Fully connected layers for predicting vertex coordinates
- Output: (Batch Size, 10.000, 3)



Boost



Training Highlights

- Optimizer: Adam (Learning Rate = 1e-4).
- Loss Function: Mean Squared Error (MSE).
- Duration: 30 epochs.
- Results:
- Average Chamfer Distance: ~0.6.
- Average Hausdorff Distance: ~0.9.

$$\frac{w_1}{|P_1|} \sum_{p_{1i} \in P_1} \min_{p_{2j} \in P_2} (||p_{1i} - p_{2j}||_2^2) + \frac{w_2}{|P_2|} \sum_{p_{2j} \in P_2} \min_{p_{1i} \in P_1} (||p_{2j} - p_{1i}||_2^2)$$

$$d_{\mathrm{H}}(X, Y) = \max \left\{ \sup_{x \in X} d(x, Y), \sup_{y \in Y} d(X, y) \right\},$$

Boost

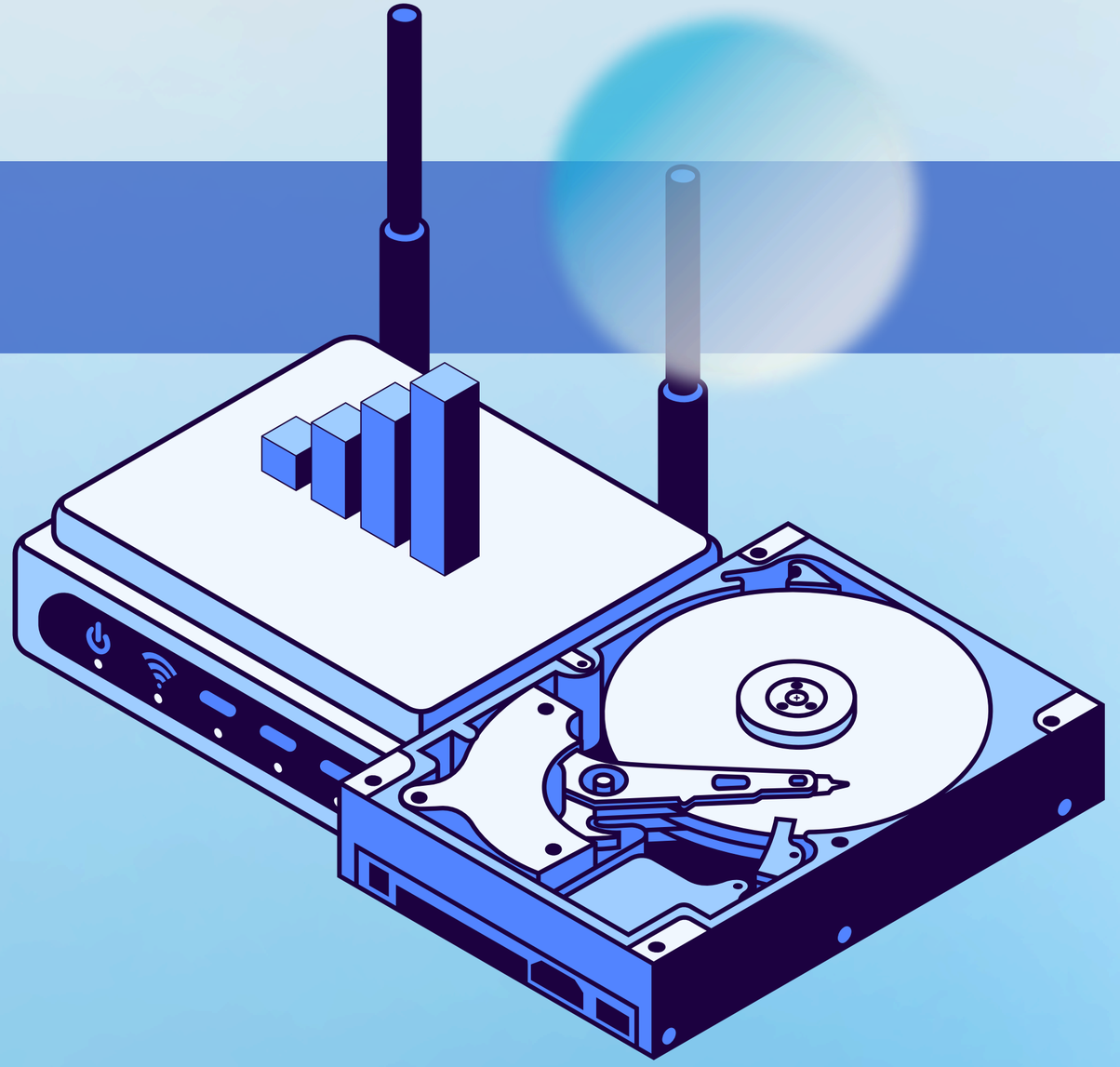
Challenges

Computational Limitations

- Only 1 512 GB laptop available
- Processed files individually during testing
- Unable to compute Hausdorff Distance for 1 scan due to system shutdown

Future Improvements

- Increase computational resources (e.g., multiple laptops or cloud computing)
- Enhance code efficiency for batch processing



Boost

Results and Discussion

- Relative to input size and complexity, results are a starting point.
- Demonstrated feasibility of deep learning for 3D surface mesh estimation in NDT.

Boost

Acknowledgements

- DarkVision: For providing the dataset and organizing the challenge.
- UBC Data Science Club: For hosting the competition and fostering collaboration.

BOOST

Thank You!

Get In Touch With us

GitHub repository