Complex data analytics in augmented manufacturing environments

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Industry Challenge

Commonplace methods for measuring large assemblies that are prone to change have revolved around manual measurements. There is a growing need for utilising data measurements in a digital format, whilst doing so would expedite compliance checking of potential conflicting parts earlier in the manufacturing processes found in large scale metrology. This work aims to streamline and automate a section of this process enabling more fluid dimensioning of the pipe components within a scaled-down physical prototype pipeline model (Figure 1). This work aims to increase the flexibility of segmentation, introducing computer aided design (CAD) parts into the scene to aid compliance checking when working with partial scans.

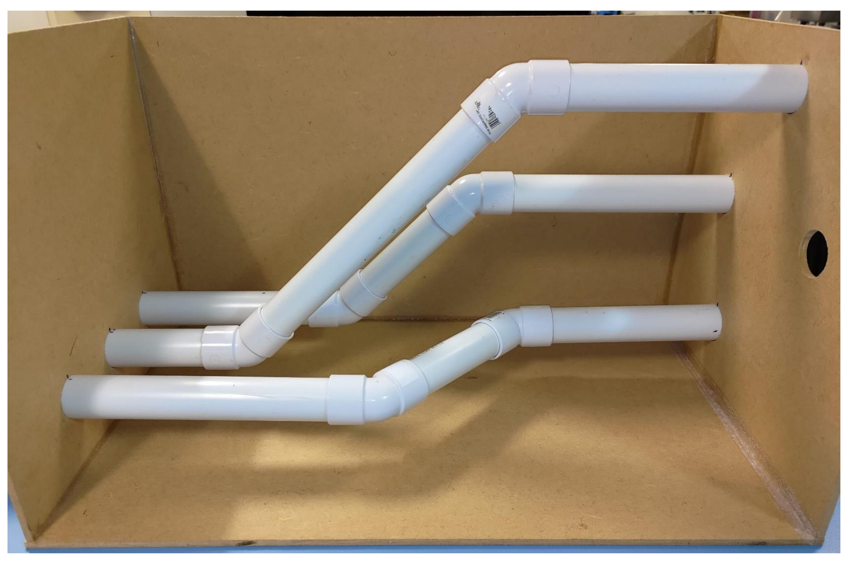

Figure 1: Physical model

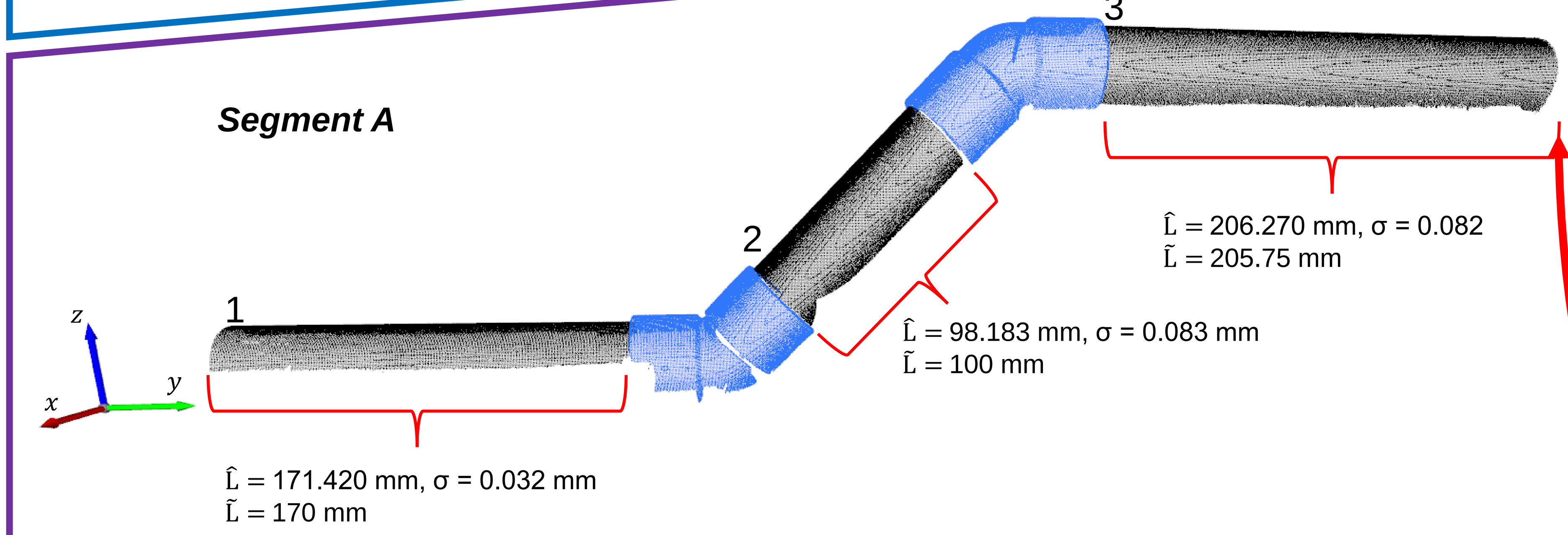

Figure 4: Segment A cylindrical sections (gray points) segmented by removing elbows (blue points).

Goals

- Reduce operator time when scanning.
- Reduce a priori for cylinder dimensions.
- Using CAD information from elbow (Figure 5).

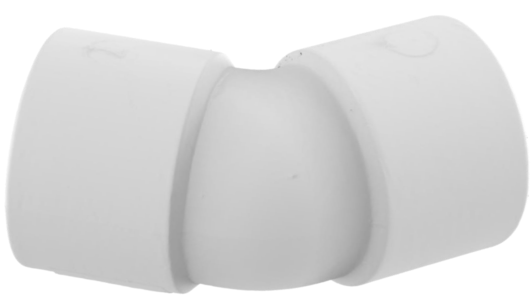

Figure 5: Elbow 3D scan

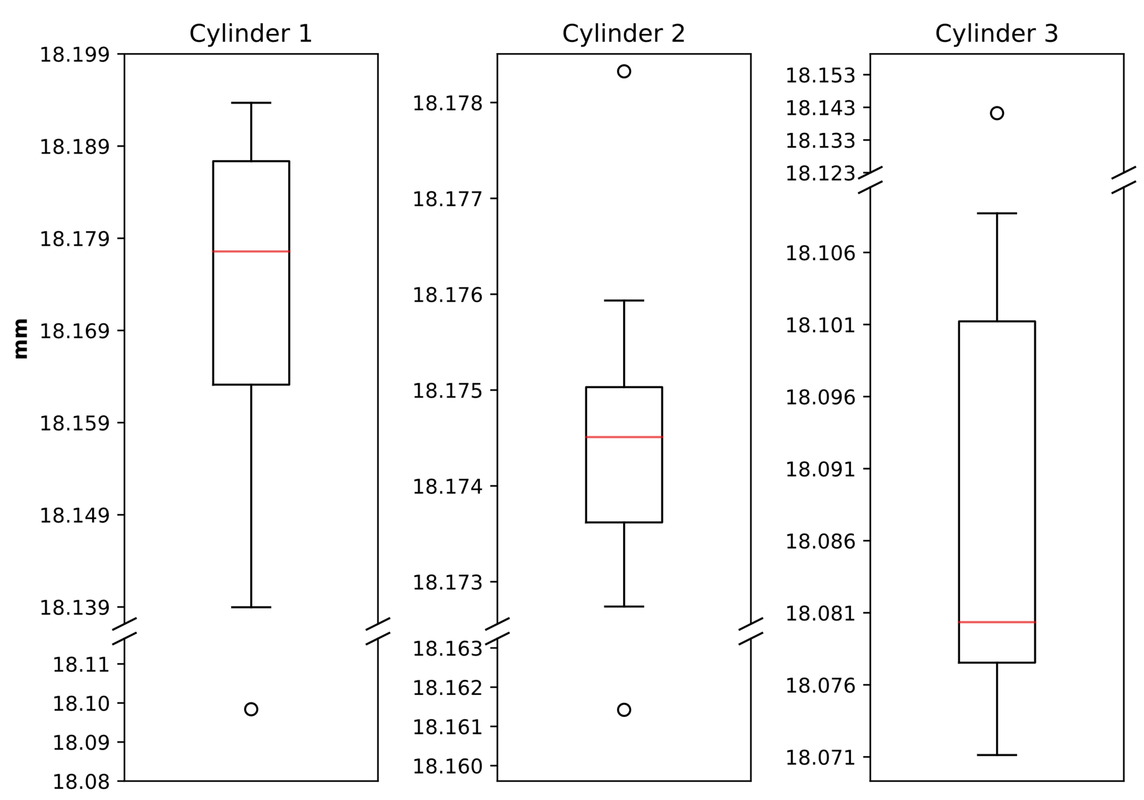

Figure 6: Segment A pipe radius boxplot

Proposed Research

A physical pipeline prototype model (3PM) seen in Figure 1 and its corresponding CAD model was created for comparisons (Figure 2). The individual pipes have an outer diameter of 36 mm and a length depending on the translational movement allowed within the box. Using a FaroArm laser line probe, a scan was carried out on the 3PM (Figure 3).

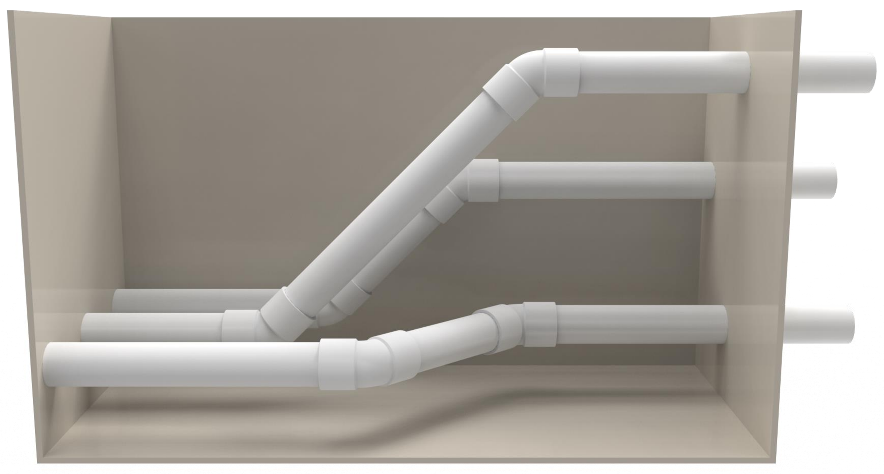

Figure 2: 3PM CAD model

Steps:

- Random sample consensus (RANSAC) [1] of a plane is used to segment the four main sides found around the 3PM.
- Noise filtering via the statistical distance of the points when compared to the mean in the point cloud.
- Density-based spatial clustering of applications with noise (DBSCAN) [2] is performed for grouping of the three different segments.
- Fast point feature histogram (FPFH) local descriptor [3] is computed for all three segments of the clusters as well as, the elbow model with roughly the correct coordinates in space obtained from the CAD.
- Angle differences between the axis of each cylinder is computed relative to the XY, YZ, and XZ planes creating a new local axis.
- Algebraic circle fitting by Taubin [4] has been deployed for the individual sliced cylinder sections (Figure 9).

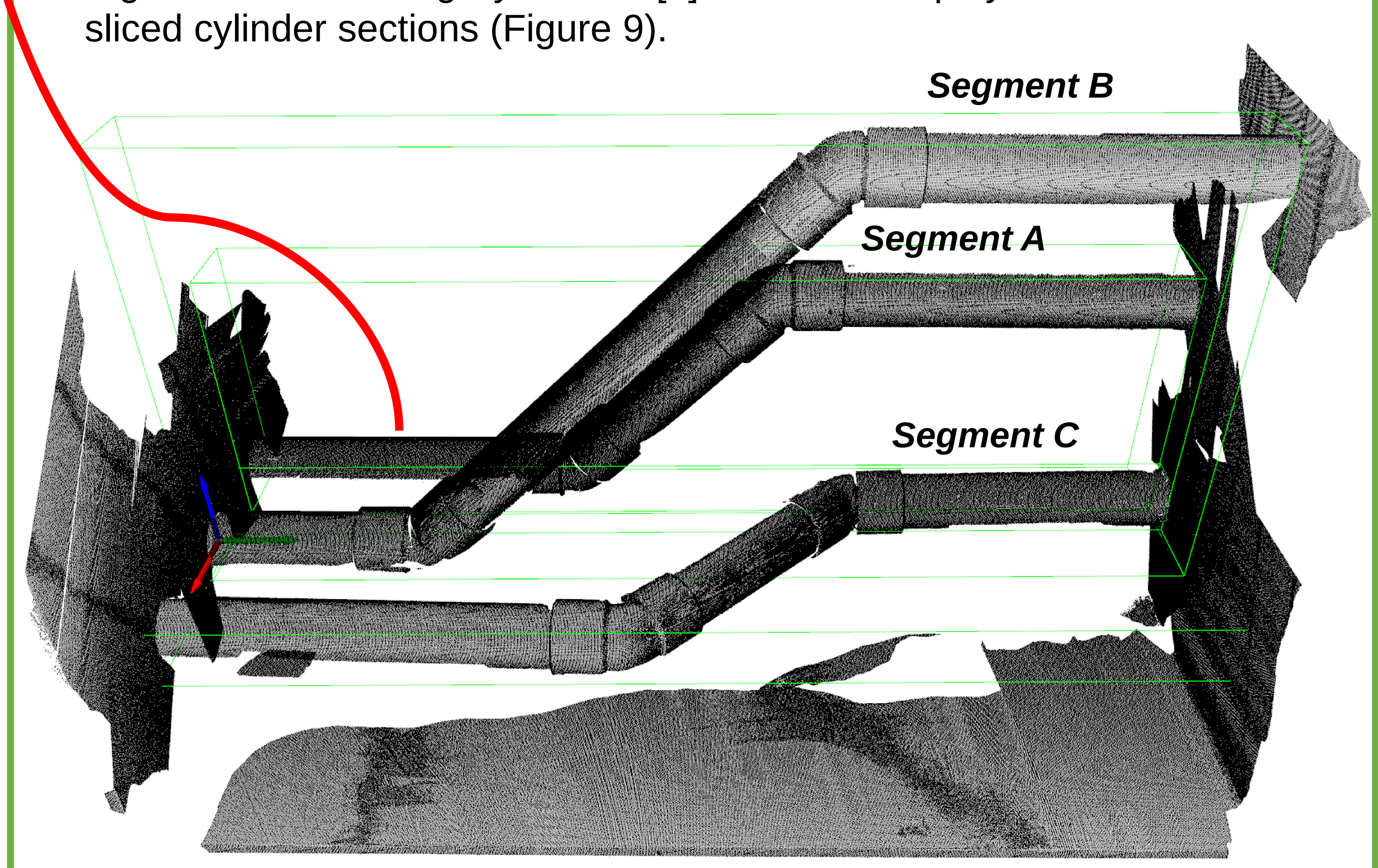

Figure 3: 3PM Faro scan

Results

The procedure provided segmentation results for the cylinders (pipes), as well as accurate positioning of the cylinder centres (Figure 7) and radii (Figure 6) for segment A. Cylinder two is observed to contain the lowest deviations of the circle fits, attributed mainly to the higher partial surface area scanned when compared to the other partial cylinder. Nonetheless, cylinder one and three circle fits proved to be accurate with acceptable deviations.

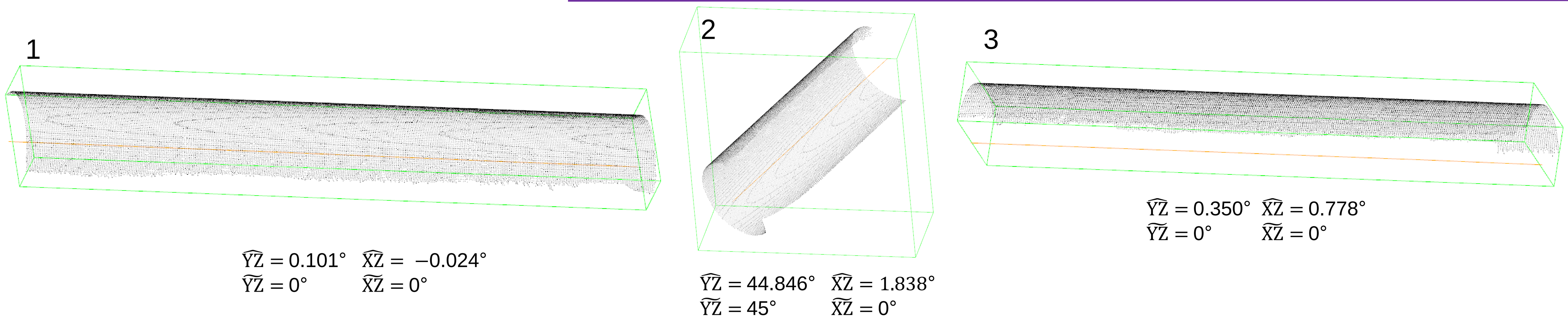

Figure 7: Segment A cylinders where axis aligned bounding box = green and centreline = orange

Outcomes/Impacts

This early work has demonstrated automation for a 3PM to aid dimensioning with the help of a reference elbow model. The procedure was applied successfully segmenting components from a point cloud pipeline without user interaction providing radius and length information. In this work both real and synthetic (using the Helios++ scanner [5]) data was applied for the trialing of the pipeline. The intended outcomes would improve documentation, automation, and reliability of measurements incorporating future models (Figure 8).

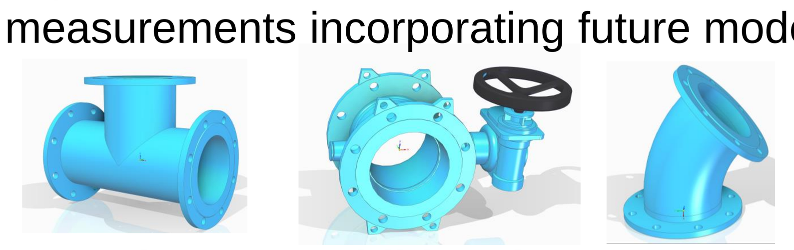

Figure 8: Additional CAD models

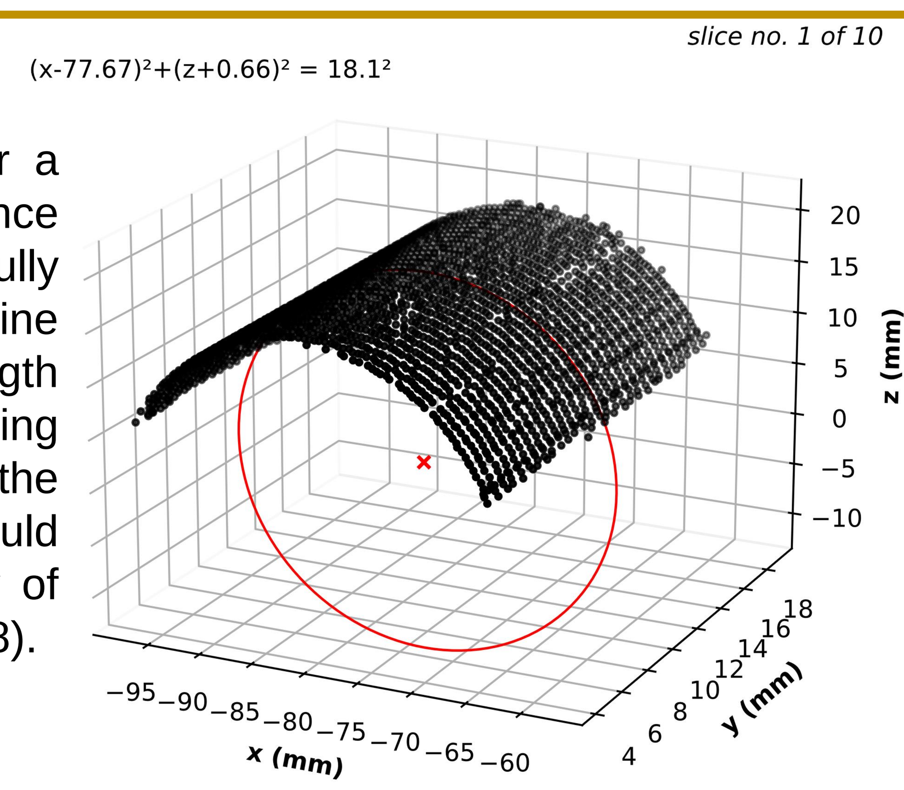

Figure 9: Taubin circle fitting on Cylinder 1

References

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