# Assessing the Utility of Point Cloud Smoothing for Additive Remanufacturing

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## Project Introduction

Additive remanufacturing provides a sustainable solution to the problem of disposing end-of-life cores. It allows damaged parts to be recovered via a condition assessment and localized additive manufacturing procedure. To accurately assess part damage, high resolution scanners capture a point cloud representation of the part of interest. This scan is then processed, analyzed, and a recovery decision is made. This project focuses on improving processing methods to generate a more accurate part model. Specifically, researching how smoothing operations affect defect detection in damaged cores.

## Relation to Sustainable Manufacturing

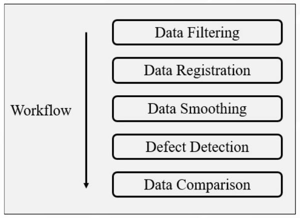
Sustainable manufacturing targets economic development, social development, and environmental protection at a systems level over the entirety of a product's life-cycle. Additive remanufacturing is one example of a process that addresses this cradle-to-cradle philosophy. Accurate damage inspection and assessment is critical to increase efficiency and reduce cost in the additive remanufacturing process. Laser scanning technologies are helpful in these assessments but challenges in data processing remain.

## State of Knowledge

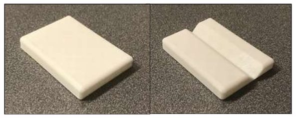
This research aims to contribute to an additive remanufacturing framework proposed by Dr. Rickli. Point cloud smoothing in the digital thread has been studied, however, it's application to condition assessment of damaged parts is limited.

## Methodology

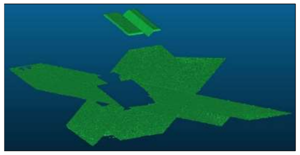
To effectively study the role of smoothing in damage detection accuracy, the scans must be properly pre-processed.



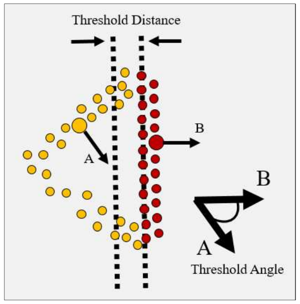

Previous work done with point clouds establishes a common processing workflow. The adjusted workflow is shown in the figure to the left. The 'Data Comparison' step will involve measuring the change in dimension of the defect as smoothing is increased.



A robust scanning strategy is used to ensure consistency. The scanned parts (left) are composed of matte white PLA to limit scan noise.

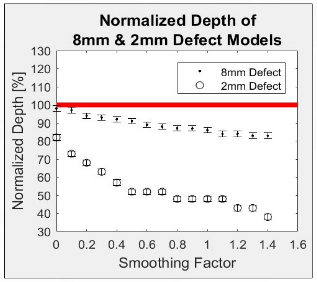


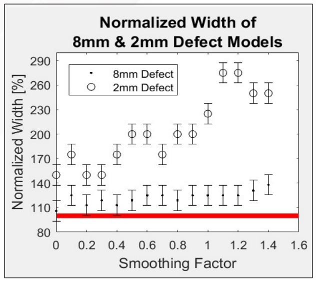
The scanned mesh initially contains unwanted surfaces and noise that must be removed. The damaged model is then registered and smoothed.



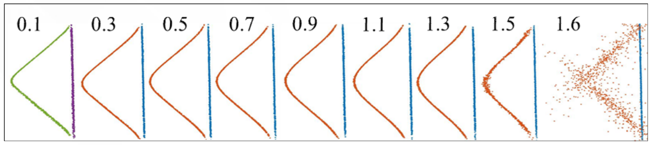

To isolate a defect region, a Threshold Distance & Threshold Angle strategy is used. Any point not meeting this criteria is assumed to contribute to a defect region. Isolation is key to analyzing the effects of smoothing.

## Results




(Above) The left and right figures show the variance in depth and width of the defect region as the smoothing factor is increased.




The figure above depicts how the point cloud geometry evolves through the smoothing process. Note, the point clouds are not to scale.

## Conclusions

- Localized smoothing is ineffective in smoothing defects
- "Surface" defects prove more difficult to capture, and create inaccuracies in determining the bounds of an affected region
- Proper smoothing is essential to additive reman. framework
- Future work will involve creating a more robust defect-detection algorithm and evaluating other smoothing strategies

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