Estimating Poses with Confidence in Robotic Metrology for Additively Manufactured Parts

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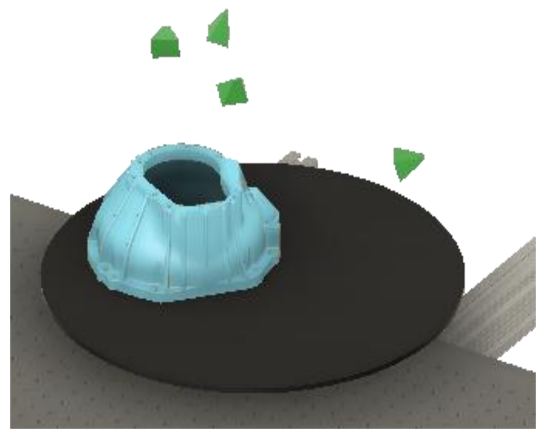
Introduction

Goal

The project aims at developing a **Robotic Metrology pipeline for high precision scanning** of additively manufactured parts.

The objective of the pose estimation module within the metrology pipeline is to accurately determine **the spatial orientation and position** of components.

Required Pose



Actual Pose

Motivation

- Viewpoint Planning is **dependent on the pose** of the object in the simulation.
- The evaluated viewpoints need to be adjusted for the actual pose of the object on the scanning table.
- Ignoring this causes **redundant scanning** runs and **occlusions**, preventing a complete object coverage.
- An initial pose estimate is required to transform the generated viewpoints

Previous Work

Monocular Pose Estimation with Local Color Histograms (Tjaden et al.)

- Prerequisite background and object knowledge
- Time expensive

Cluttered Scene Object Pose Estimation using PoseCNNs (Xiang et al.)

- Low accuracy threshold of the estimated poses
- Prone to local minimums

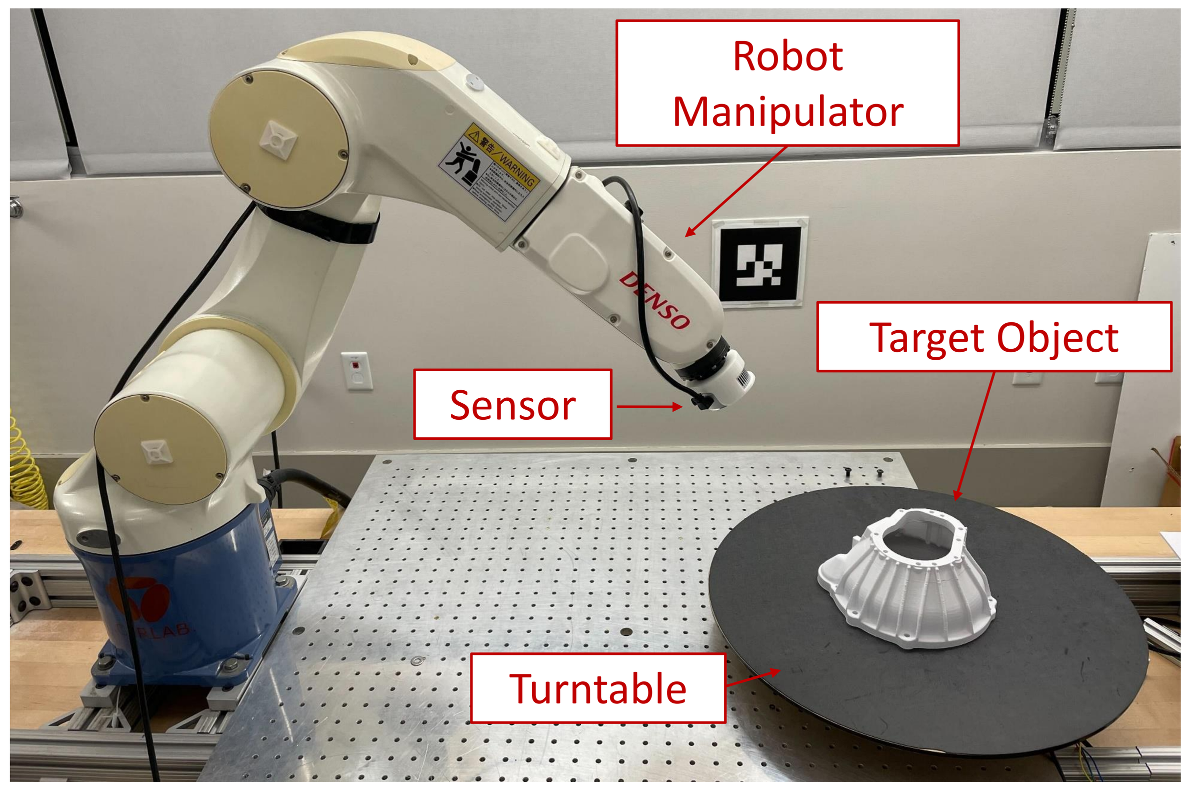
Quality Analysis of Matched Point Clouds of Objects (Bogoslavsky et al.)

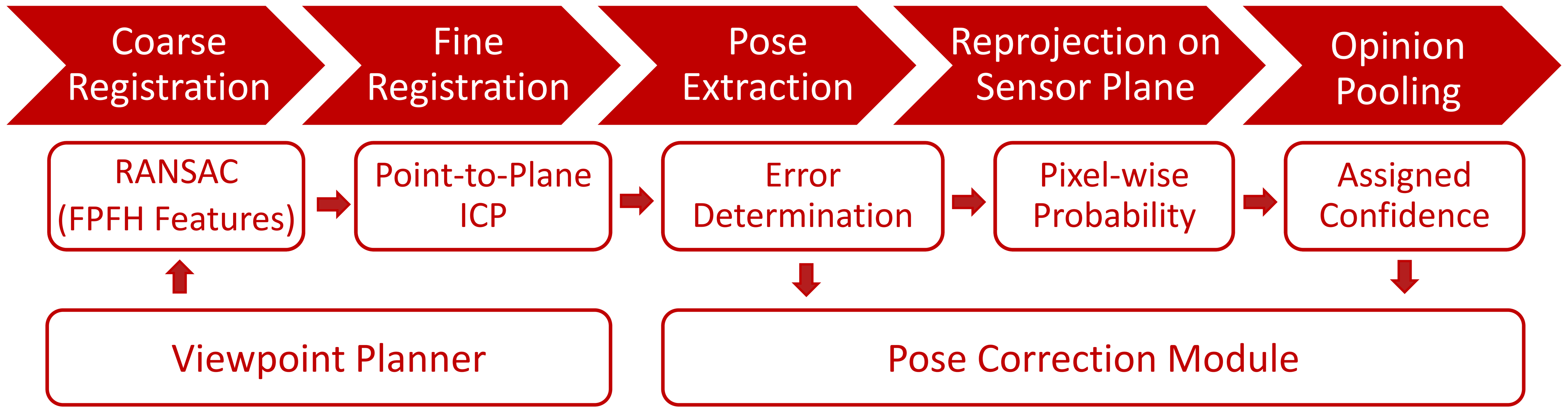
- Developed for scene rich LiDAR scans
- Highly sensitive to sensor noise

Proposed Methods

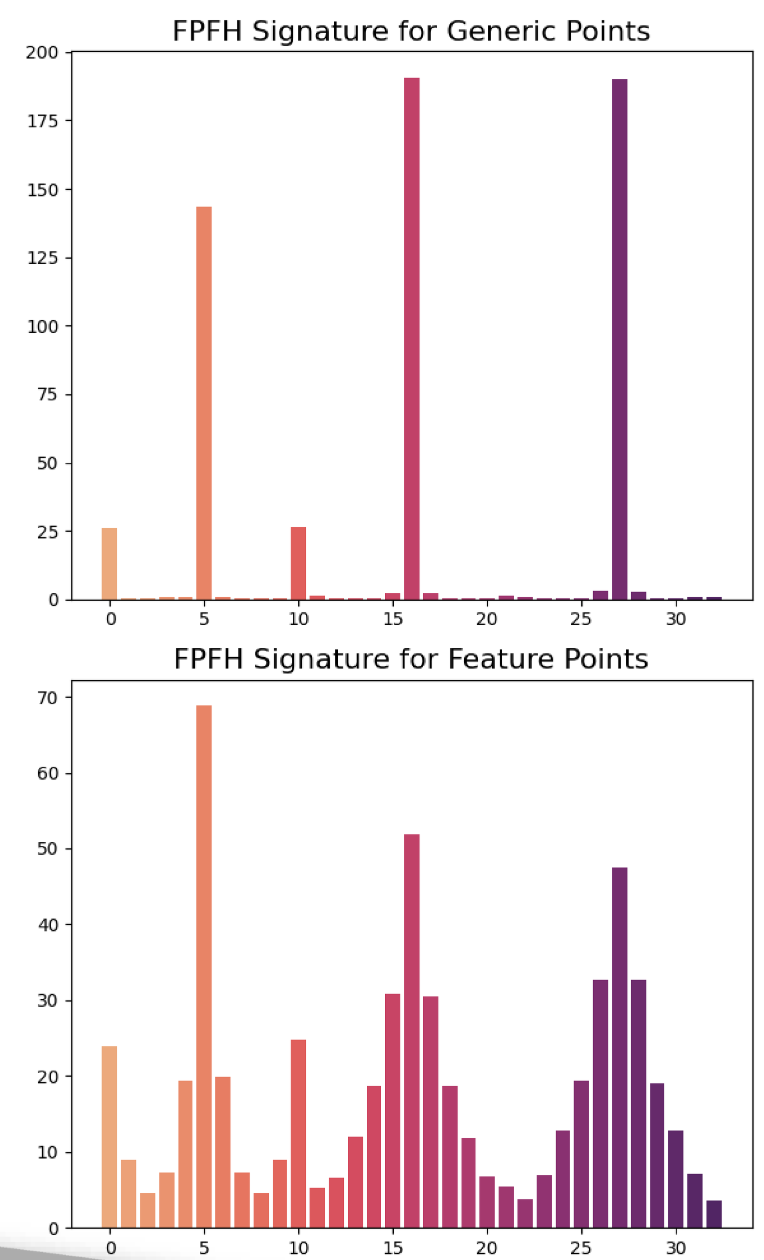
Algorithm

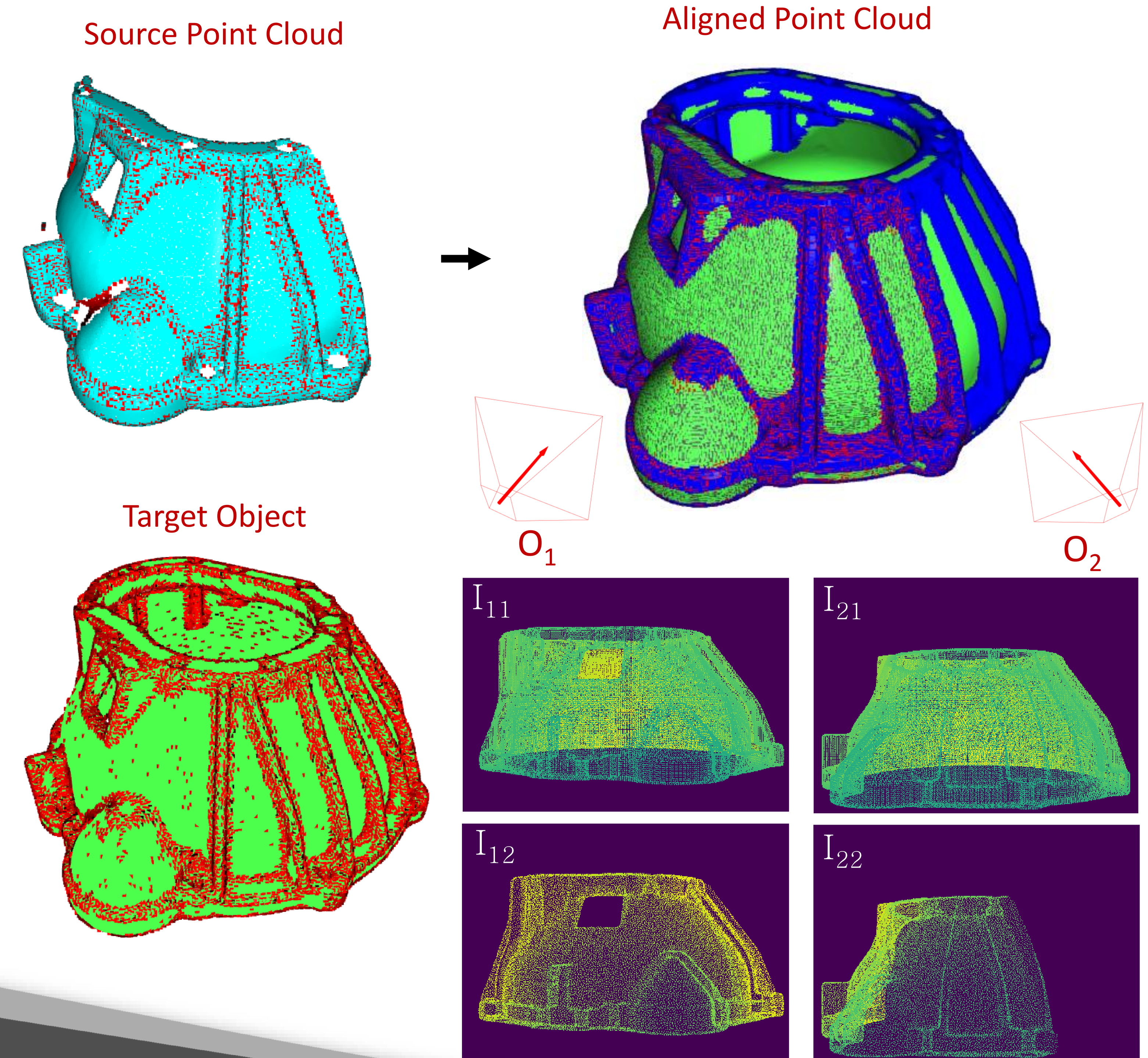
- **Coarse Transform** using Fast Point Feature Histogram of the down-sampled cloud, provided to Random Sample Consensus based alignment module.
- **Fine Registration** using Point-to-Plane ICP with coarse transform warm start.
- **Pose Extraction** from the resulting transform used to correct the viewpoints.
- **Reprojection of clouds** on image planes at transformed origins to get four depth maps.
- **Pixel-wise probability** calculation followed by **opinion pooling** to get a confidence metric.





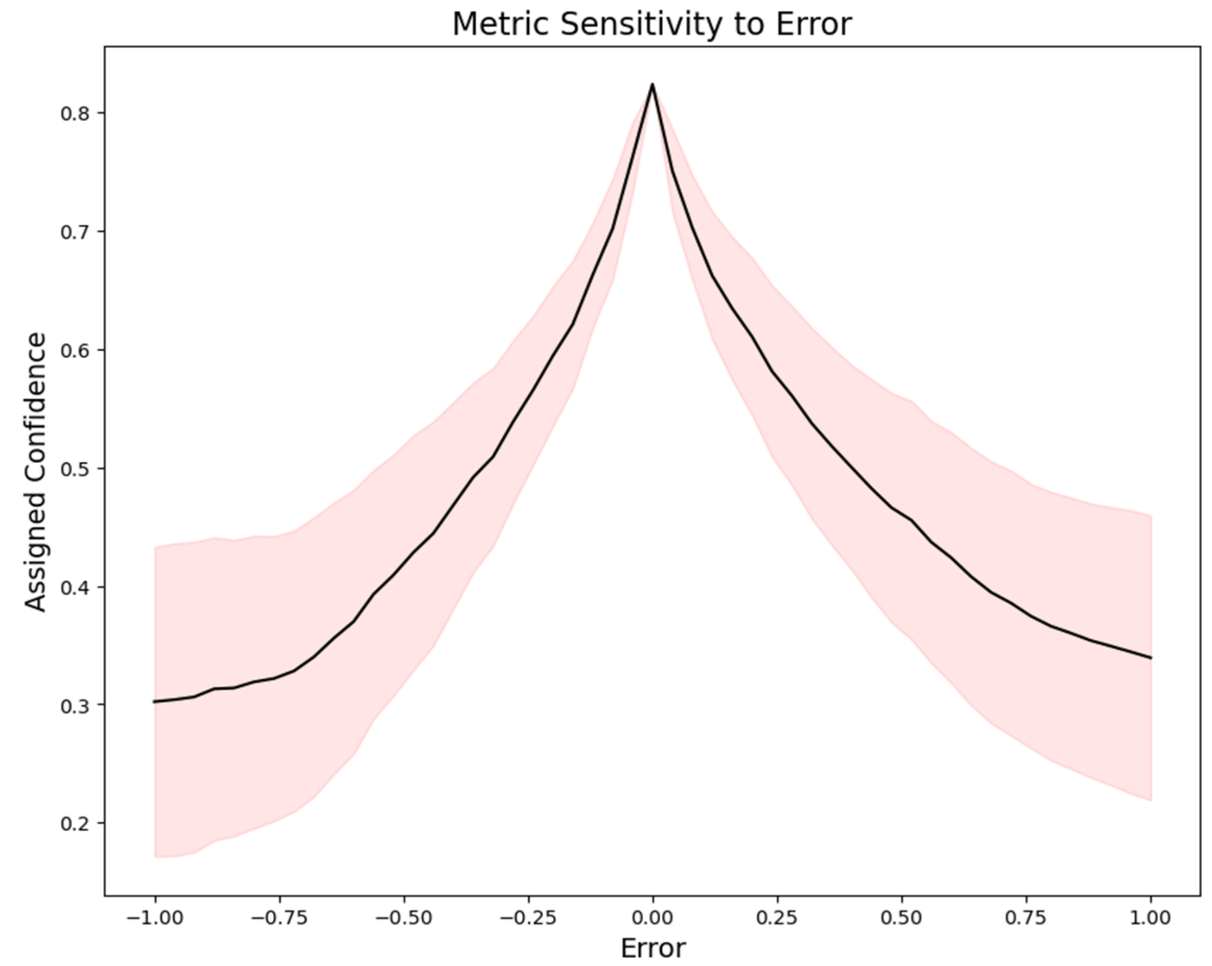
Results

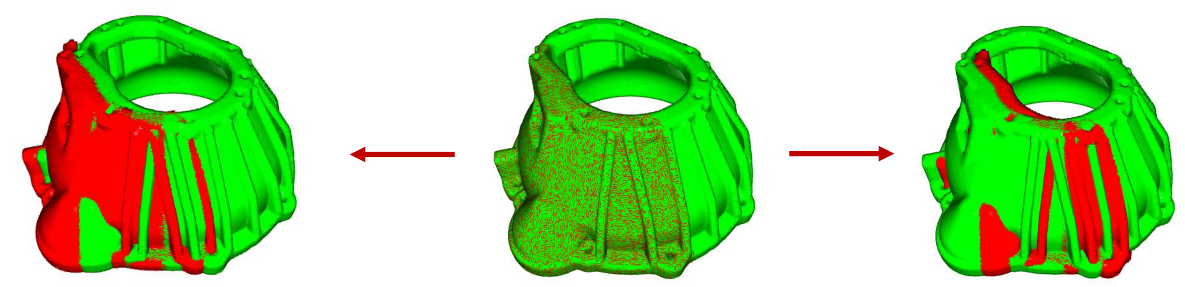




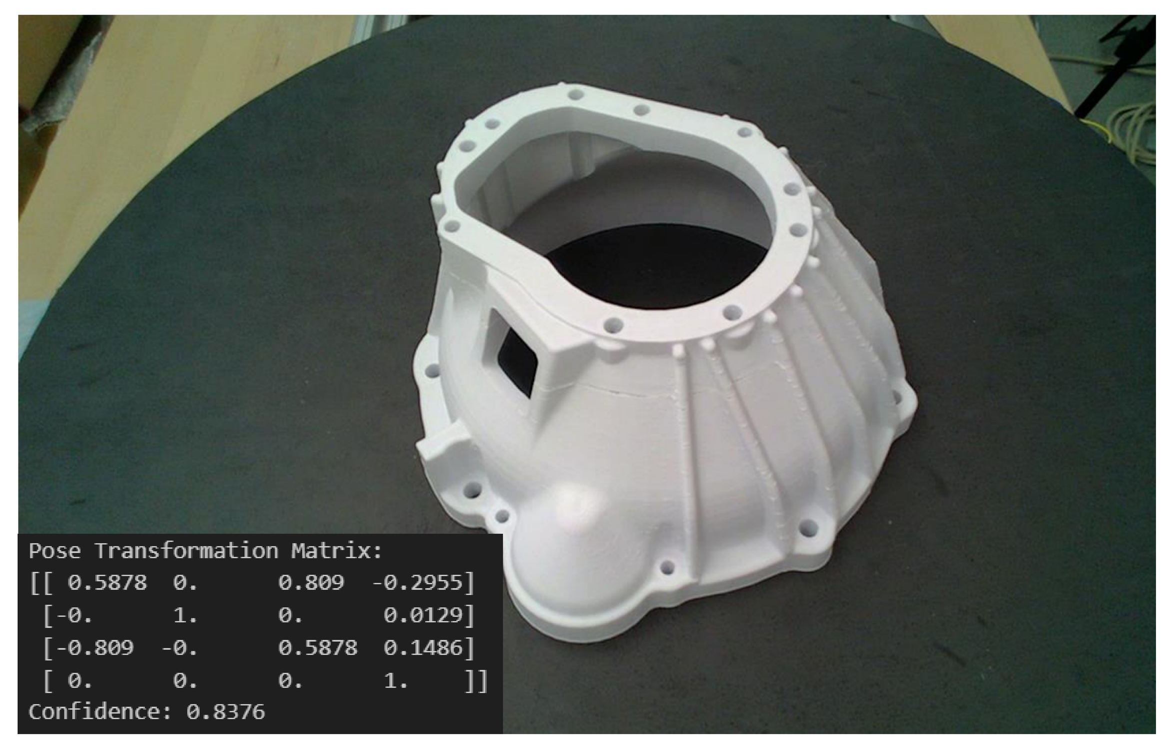
Conclusions

The Confidence Metric is **highly sensitive** to alignment errors. This was verified by introducing synthetic error to the aligned clouds.





Experiments show the error benchmark for the pose estimation module was **0.028 mm** for translation errors and **0.058 rads** for rotational error.



Acknowledgements

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