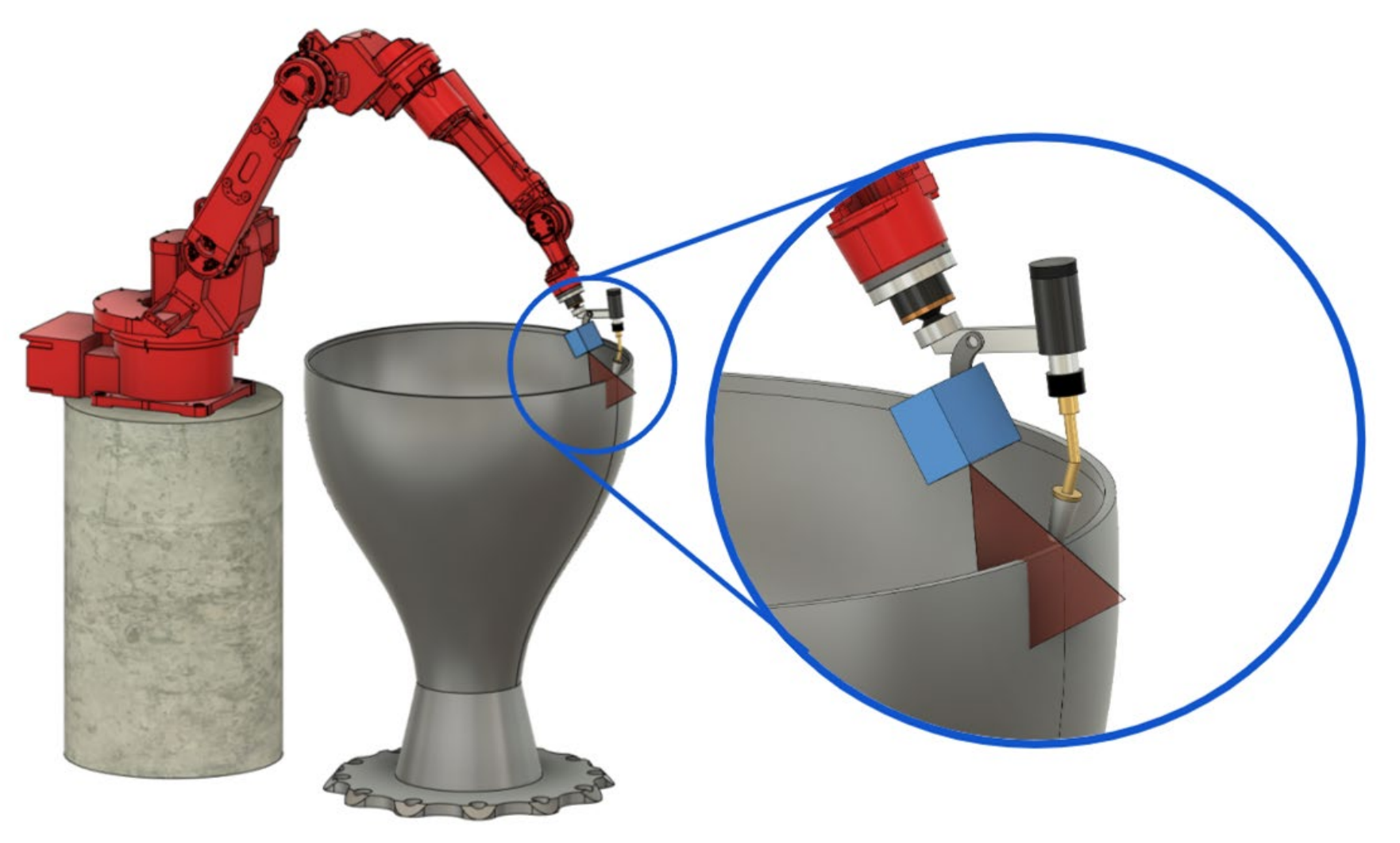




Summary

Closed-loop process inspection and adaptive path planning for Robotic Wire Arc Additive Manufacturing (rWAAM) process

- Novel sensing technique for additive manufacturing
- Online defect detection and localization during WAAM process
- 3D geometry reconstruction and online quality monitoring



Task 1. Coverage motion planning for WAAM

Task 2. In-situ Multimodal Robotic Inspection

Task 3. Design of experiments to evaluate the sensor performance

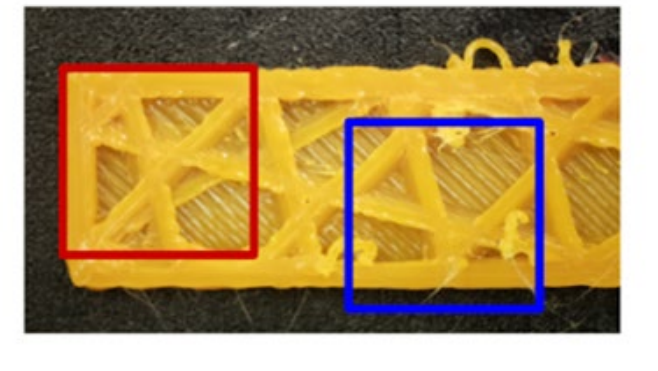
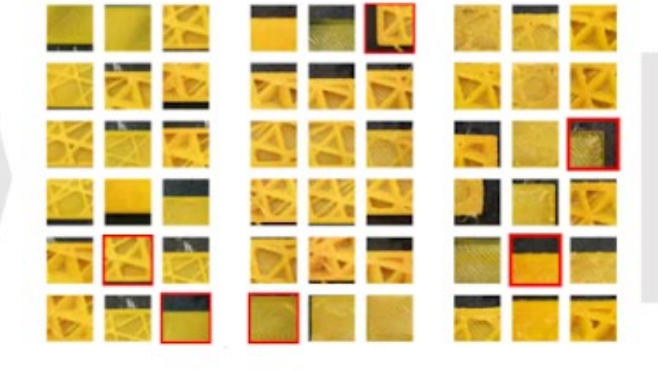
Size ↑ Accuracy ↑

Cost ↓ Time ↓

Edge Sensor for Confined Space Manufacturing

Technology Highlights

- ★ Confined space RGB-D inspection
- ★ Infrastructure free visual-inertial SLAM
- ★ Sensor for closed-loop manufacturing
- ★ Edge processing for machine learning



CMU Edge Sensor

Dataset Collection

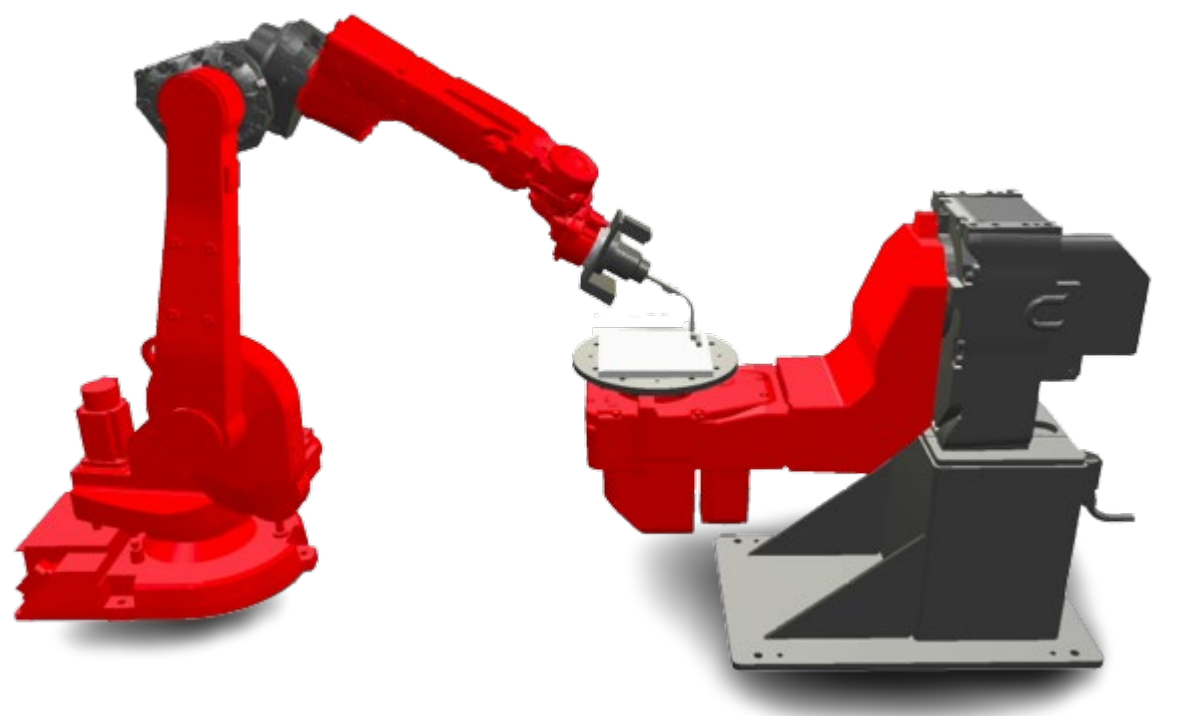
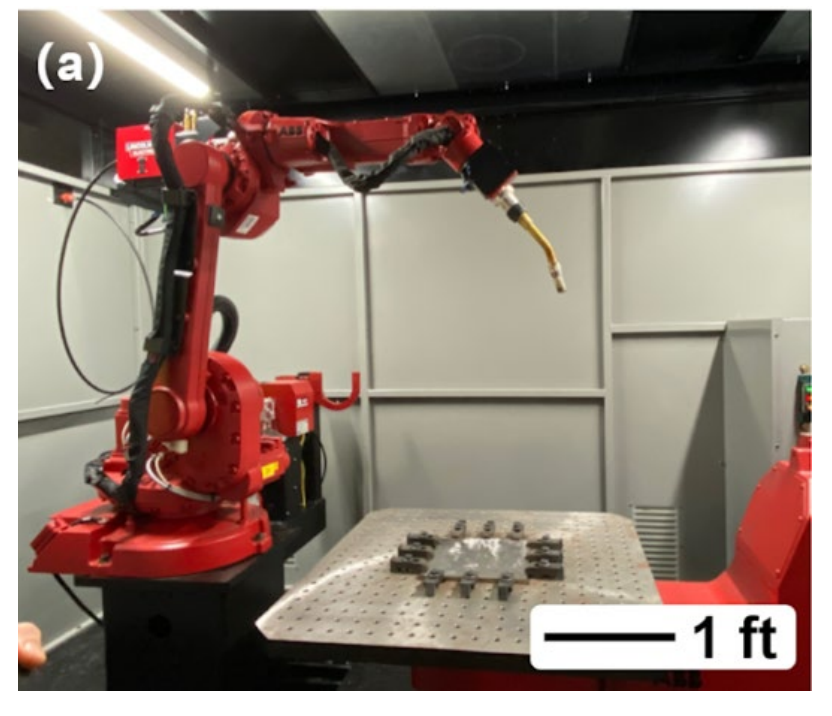
Defect detection

Experiment and Simulation Setup

- To replicate real world AM defects, “miniWAAM” workcell is developed
 - Cost effective and efficient test bed for simulating WAAM Process
 - Setup for quick prototyping and testing of algorithms
- rWAAM digital twin with ABB Robot arm and platform developed



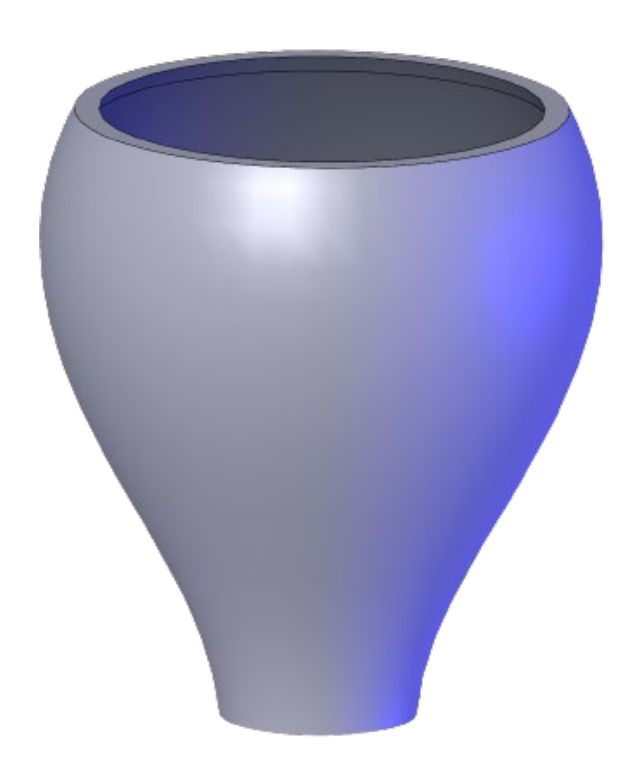
“miniWAAM” workcell



MFI WAAM workcell (left) and its digital twin (right)

Task 1. Coverage motion planning for WAAM

- Printing and scanning path generation
- Printing-Scanning software framework development
- Experiments and Demonstration on “miniWAAM” workcell



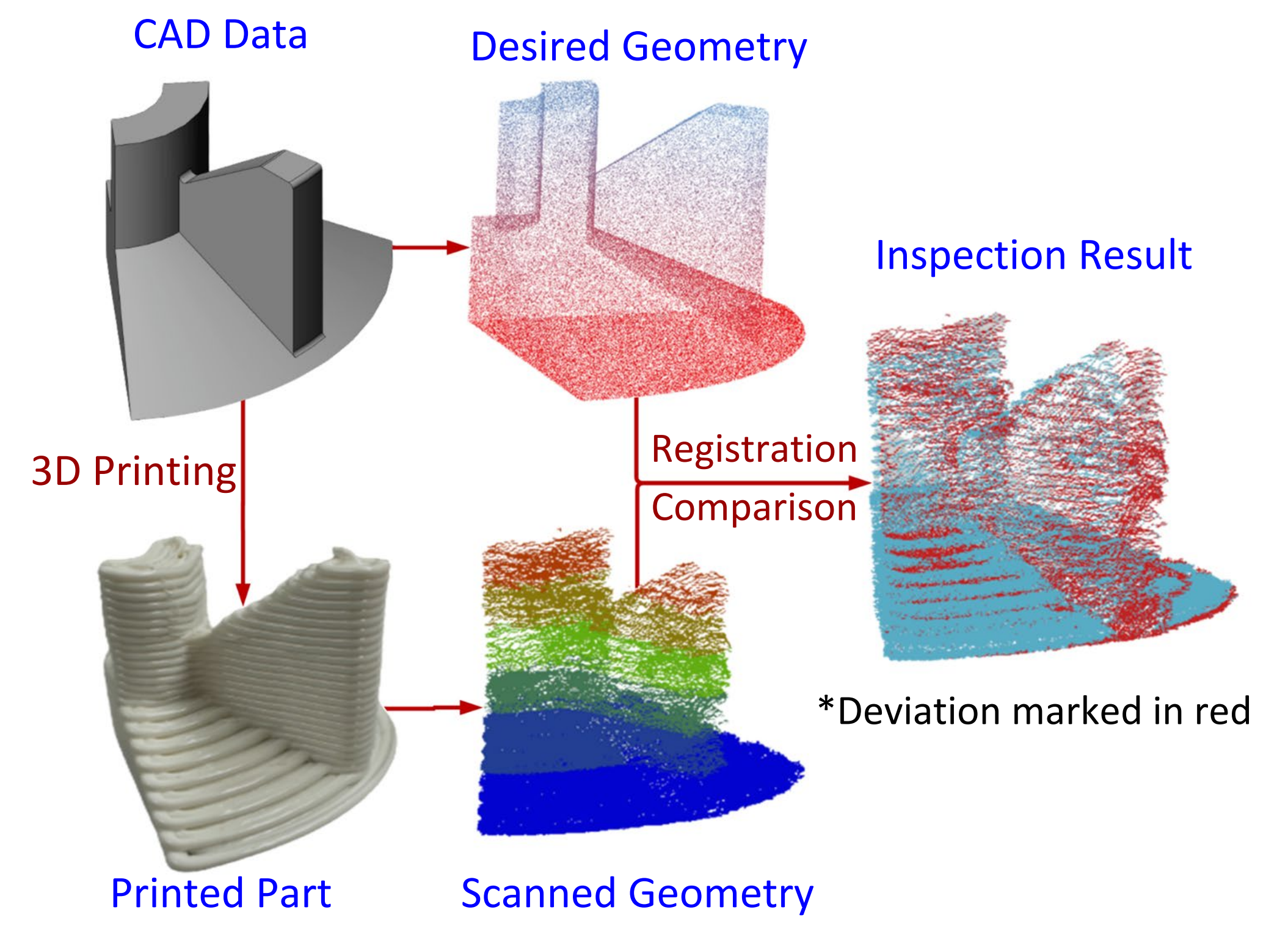
CAD Model



Printing tool path demonstrated on “miniWAAM”

Task 2. In-situ Multimodal Inspection for WAAM

- Online geometric anomaly detection
- Layer-wise pre and/or post fabrication scanning
- Layer-wise comparison with desired geometry for inspection
- In-process adaptive tool path generation to avoid defects*

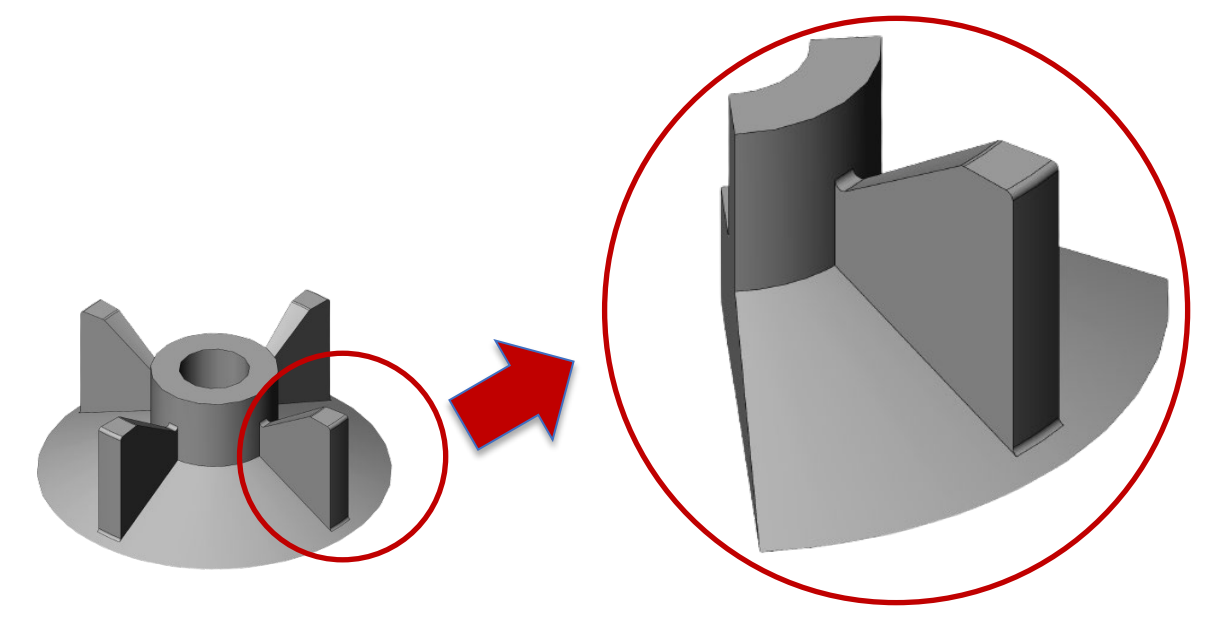


Workflow for proposed inspection method

Task 3. Design of experiments to evaluate sensor performance

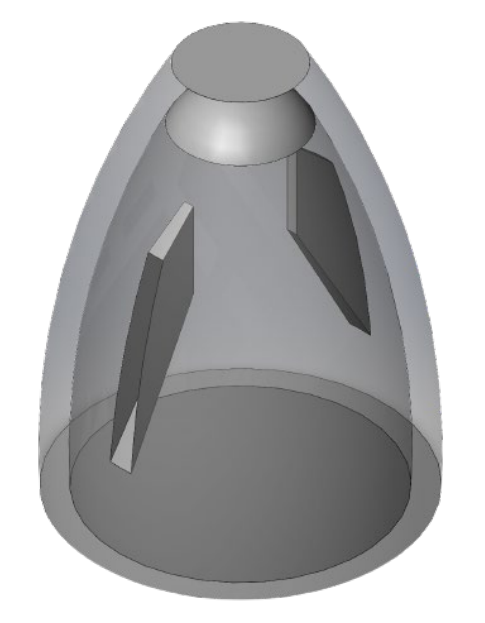
Test geometries for evaluation:

- Common tool path and surface geometries for WAAM
- Shapes that can't be inspected by conventional techniques



(a)

Test Part for performance benchmarking: Subdivision of a large impeller (a)



(b)

and part with internal structure (b)