

Background

Challenges in AI-enabled Additive Manufacturing (AM)

Lacks *in-situ* process monitoring and inspection [ARL/ NextM]

Only post-inspection → Time lost and cost
Bad generalizability → Relies on Data & Label



Lacks *in-situ* process control [Boeing]

Multivariate build process → Inconsistency
Unobservable parameters → Randomness

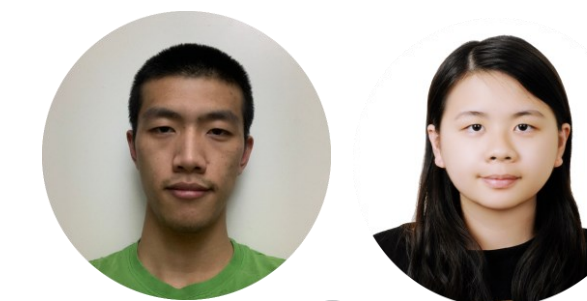


In-situ Inspection and Machine Learning for AM

In-situ Inspection using Semi-Supervised ML

Reduced reliance on expert-labeled data

Semi-supervised learning uses an unlabeled dataset for pre-training (generalizable to new skills)
Up to 10x smaller labeled database used for finetuning to specific defects detection



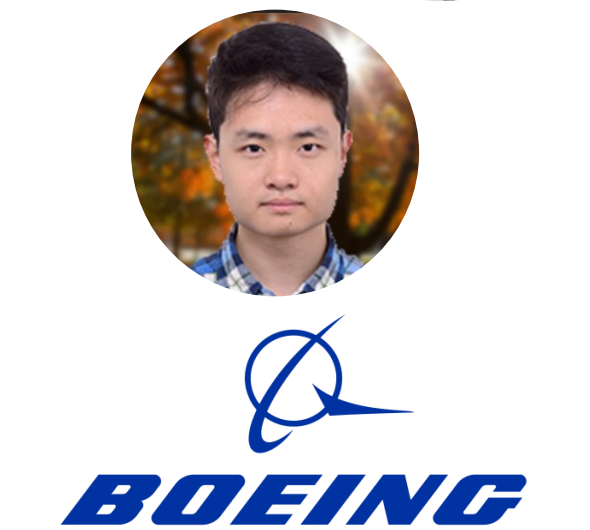
Robotic closed-loop planning and control for AM

Sensor-based Closed-loop AM Processes

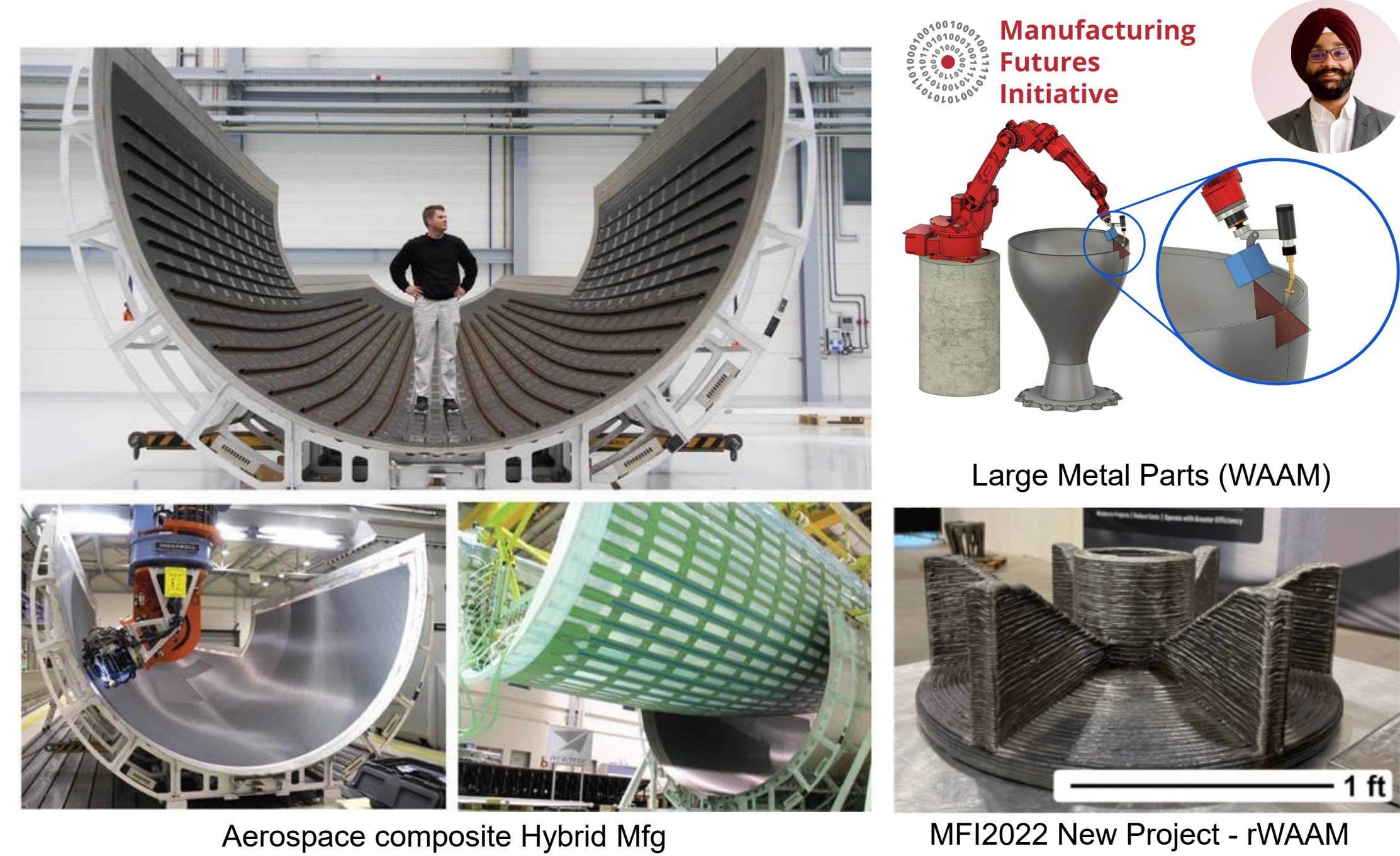
Incorporating in-process local replanning
Adapting the tool path to accommodate for defects in AM part

Sensor-based Coverage Planning

Optimal path planning for 3D scanning and printing processes using sensory information

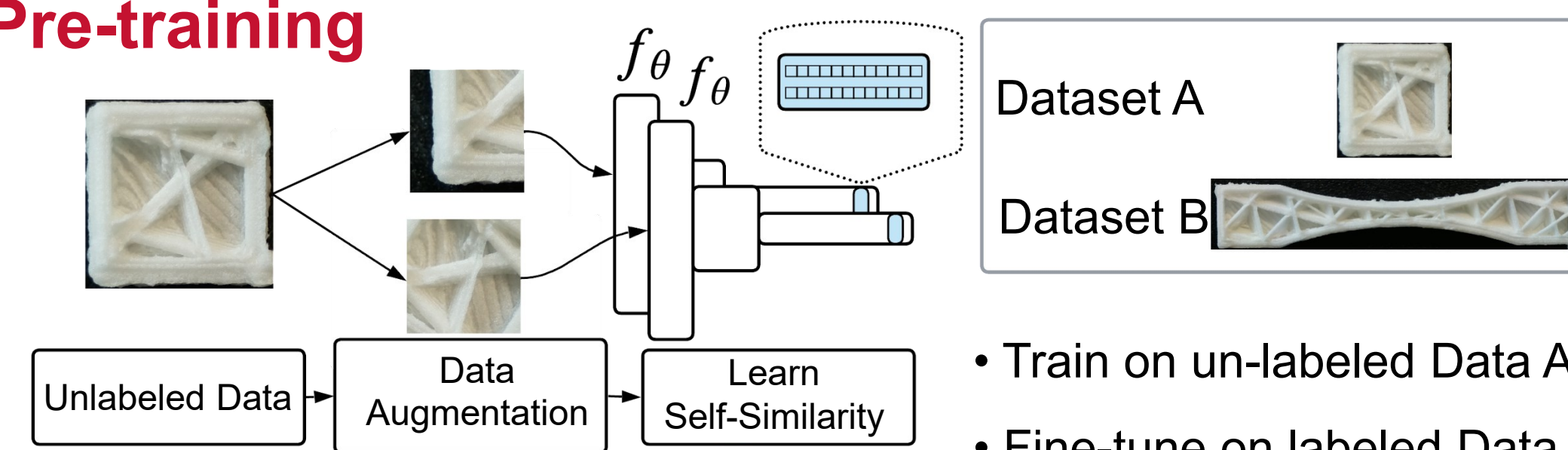


Applications

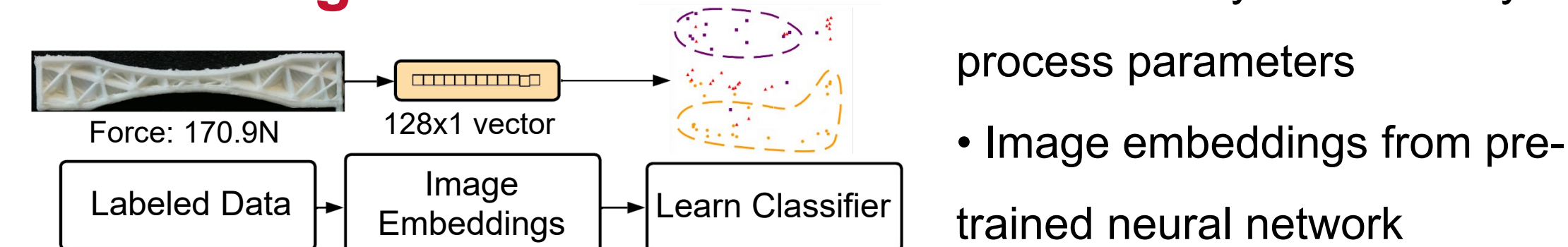


Methods: Semi-Supervised Defect Detection Framework

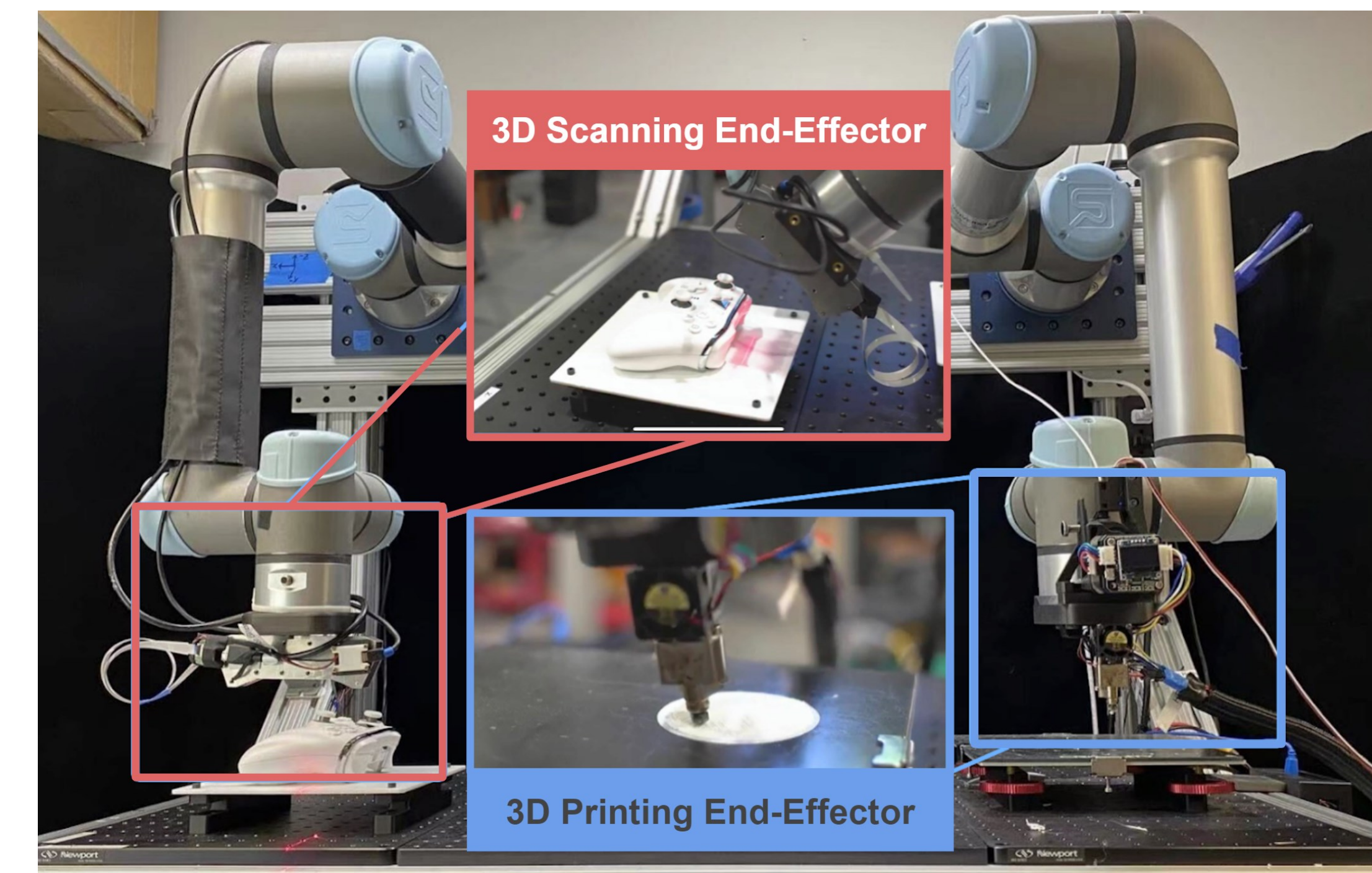
Pre-training



Finetuning



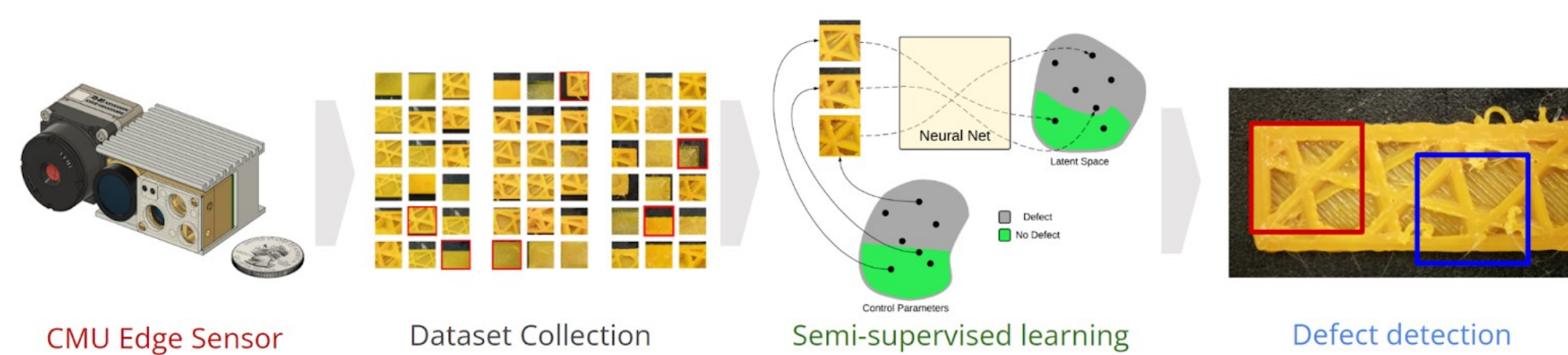
Methods: Scan-Plan-Print-Repair Paradigm



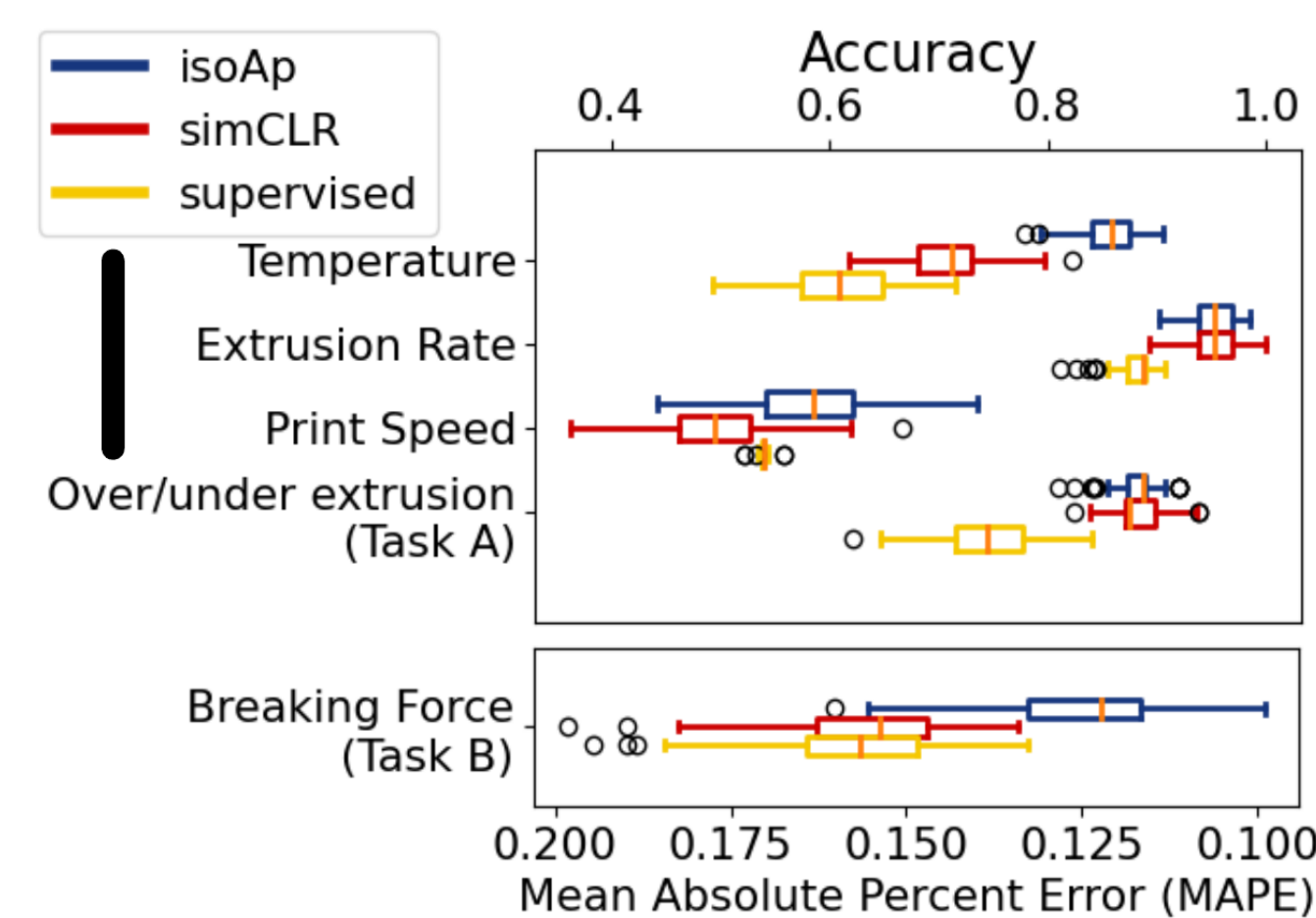
Edge Sensor for Additive Manufacturing

Technology Highlights

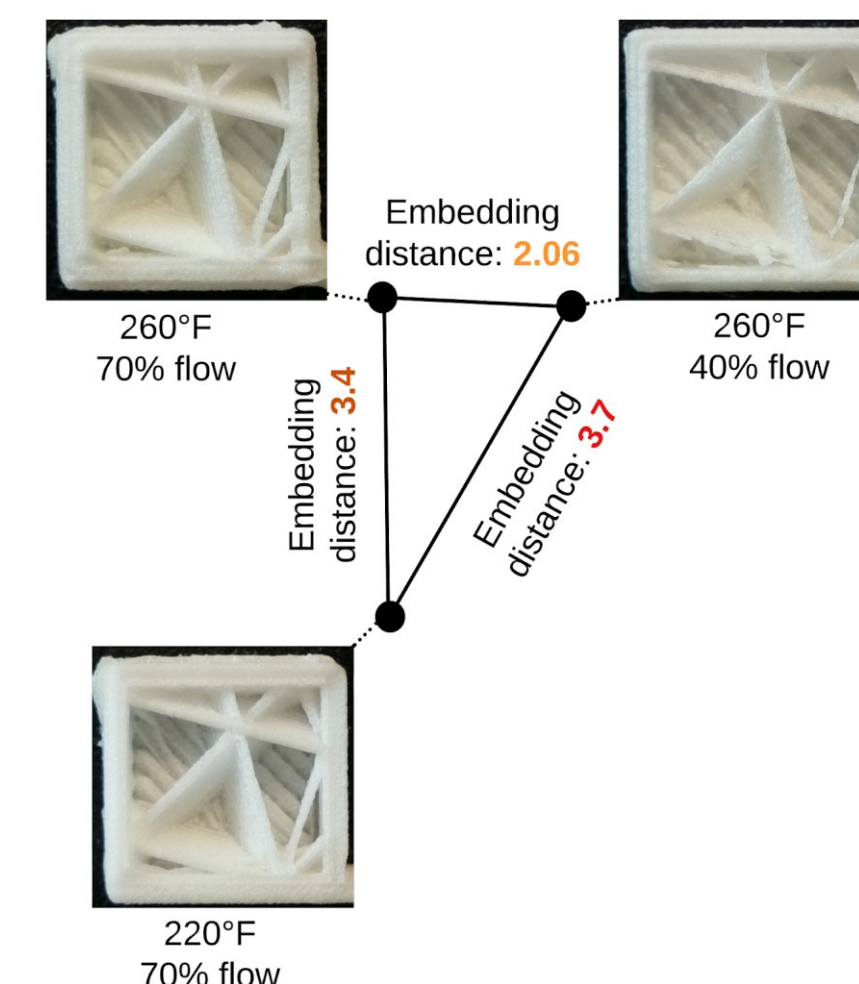
- ★ Confined space RGB-D inspection
- ★ Sensor for closed-loop manufacturing
- ★ Infrastructure free visual-inertial SLAM
- ★ Edge processing for machine learning



Results: Comparison across 5 tasks



Result: Embedding Distances

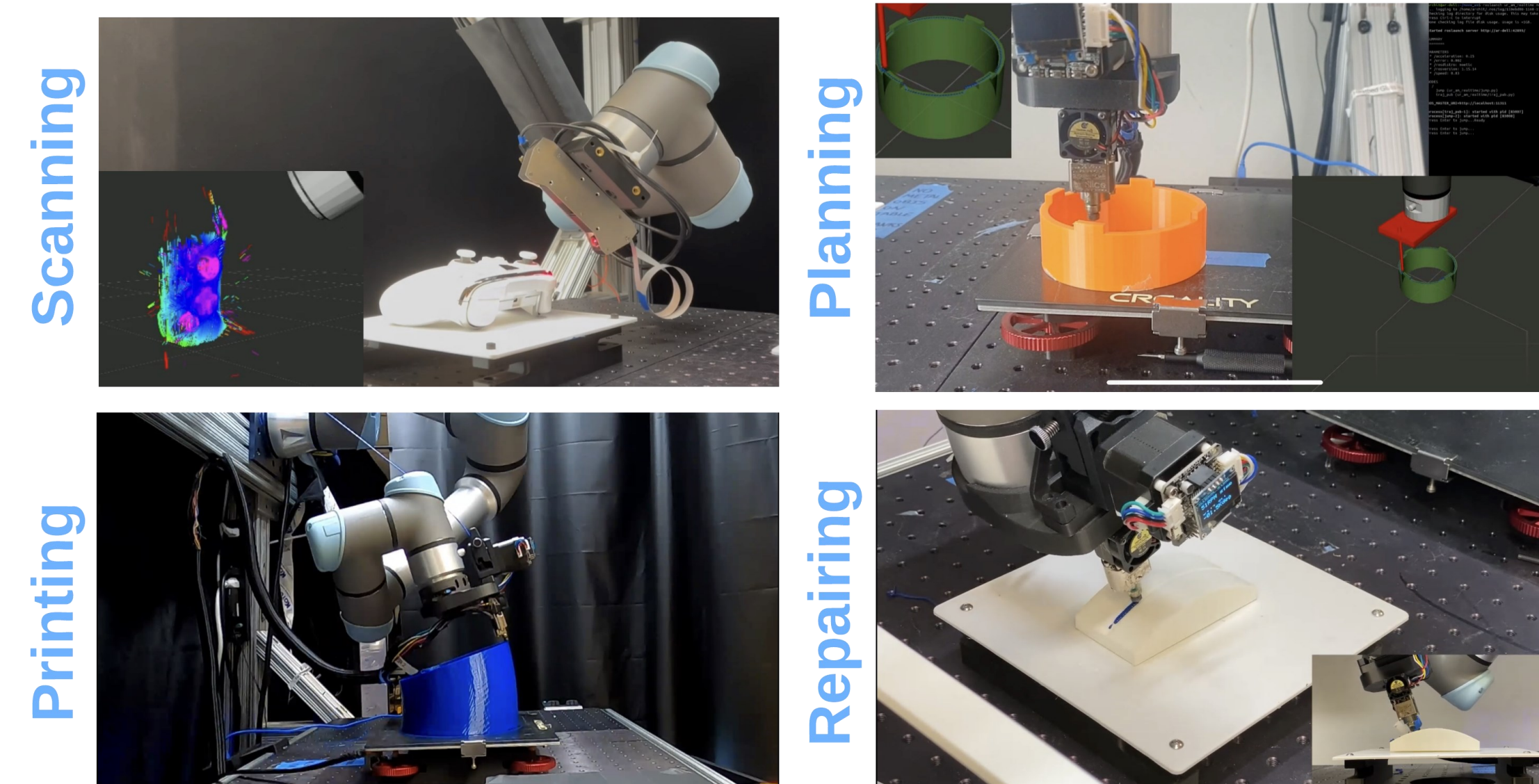


Scanning

Printing

Planning

Repairing



A portion of this research was sponsored by the Army Research Laboratory and was accomplished under Cooperative Agreement Number W911NF-20-2-0175. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Army Research Laboratory or the U.S. Government. The U.S. Government is authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation herein."