

# On-Demand AI Solutions for Forging and Surface Finishing

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2024 Annual Meeting

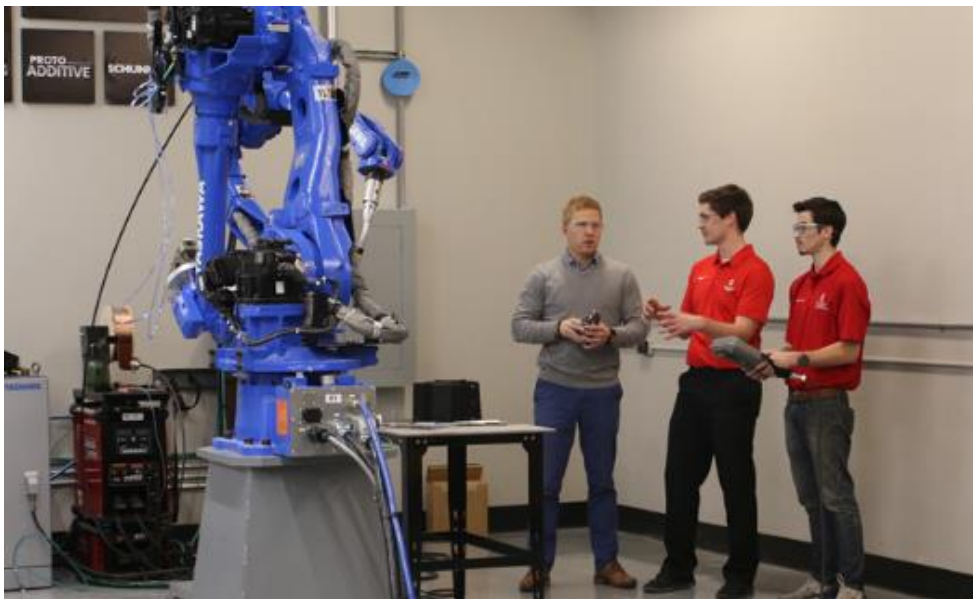
**Adam Buynak**

The Ohio State University

# Overview

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- CDME / AIMS Overview & Introduction
- AI Communication through Transparency
- DRIFT: Robotic Incremental Forging
- ARP: Autonomous Robotic Surface Finishing



## CDME in a nutshell

Applied Research and Engineering Center with a Mission of **Advancing the Manufacturing Competitiveness of the United States**

CDME 'Feels' like a Manufacturing Environment

- Multidisciplinary Project Teams
- Timeline and Deliverable Driven
- Apprentice-Style Mentorship

30 Research Staff, 8 Administrative Staff

~150 Undergraduate Research Assistants,

> 250 Affiliated Faculty and Graduate Student

47,000-ft<sup>2</sup> ITAR and HIPPA Compliant Facilities

# Building DoD's Workforce



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**Corporate Onboarding and Training**

04

**DEEP STEM**

CDME's Professional Apprenticeship

03

**Sr. Projects**

Strategic to OSU's Curriculum

02

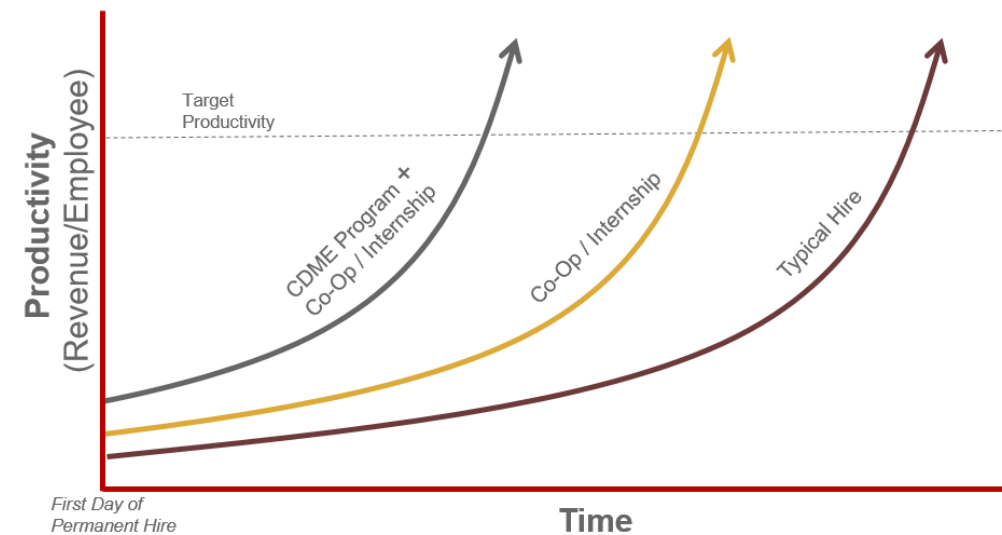
**Co-Ops / Internships**

CDME Encourages its Students to Participate in Company Programs

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**Education**

Foundational Excellence of OSU



# Experiential Education

## Project Management

- Proposal and Report Writing
- Creating a Project Plan
- Contingency Planning
- Managing to Deadlines and Milestones
- Budgeting and Cash Flow
- Legal
  - Contracts, Intellectual Property, Non-Disclosure, Trade Secrets, HIPPA, ITAR

## Project Execution

- Continuous Quality Control
- Conducting Literature Reviews
- Supply Chain / Logistics Foresight
- Fail Fast
  - Learn and Improve Without Wasting Significant Resources
- Significance of “Great” Design
  - Appeal, Size, Operation, Maintenance, Environment, Sustainability, Human Interface etc.

## Personal Skills

- Working as a Leader, with a Team, and with Constant Collaboration
- Asking for Help
- Informed Decision-Making
- Internal / External Communication
  - Setting Expectations and Communicating Issues and Progress
  - Debate with an Open-Mind





# A Need for AI-based Industrial Automation

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Industry needs robots to learn **Artisan Skills** that answer the call for..

- Increased production of low-volume, specialty parts
- Reduced burden of robot programming
- Support a shrinking, but retrainable workforce

*... without compromising the safety and observability of the system.*



# AIMS – Artificially Intelligent Manufacturing Systems

## *Primary Research Thrusts*

- Incremental Forming / Robotic Blacksmithing
- Path Planning for Surface & Seam Processes
  - Painting / Spray
  - Welding / WAAM
  - Automated Inspection
- Human-Machine Teaming & Augmented Reality

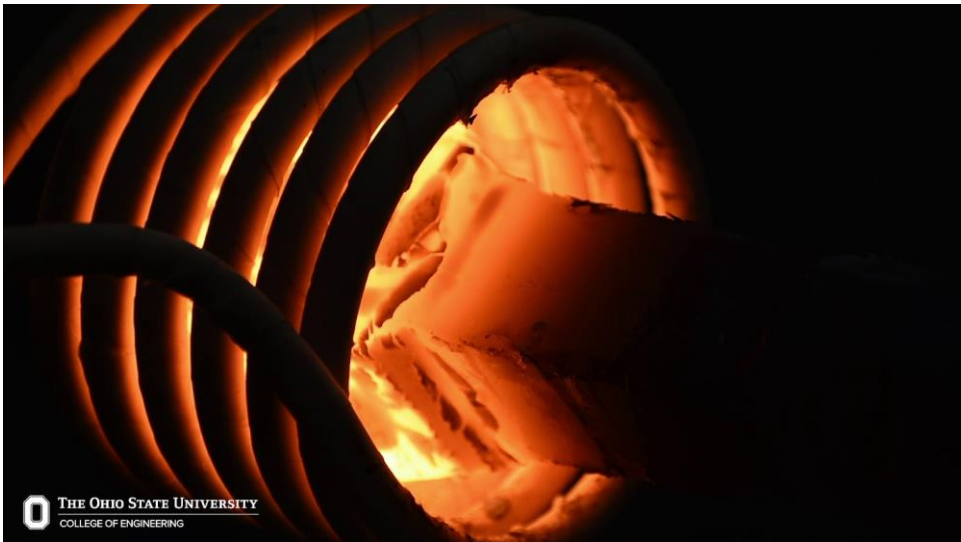
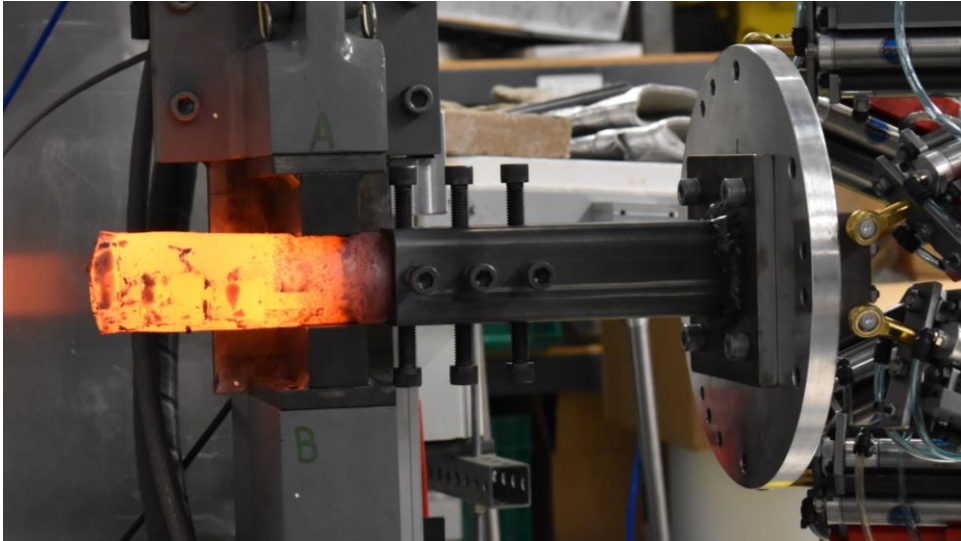


AIMS Division – Spring 2023



# DRIFT

Digital Robotic Incremental Forming Toolkit



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### **Incremental Open-Die Forging**

AIMS is exploring the future of open-die forging to enable manufacturing capability of low-volume high-strength parts.



### **Modern Day Blacksmith**

Ability to forge critical components to an optimal geometry while tailoring the mechanical properties to the desired end product.



### **In-Situ Material State Awareness**

Incorporation of real-time, inverse-design models of the feasible material state is enabled through AI-based process planning and control.



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# Autonomous Robotic Forging

December 2023 Technology Update  
Artificially Intelligent Manufacturing Systems lab (AIMS)

# Robotic Forging | Die Test Sample

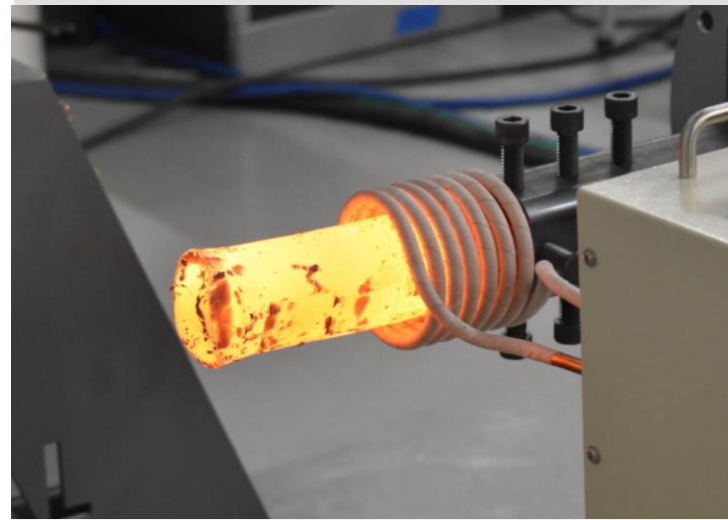
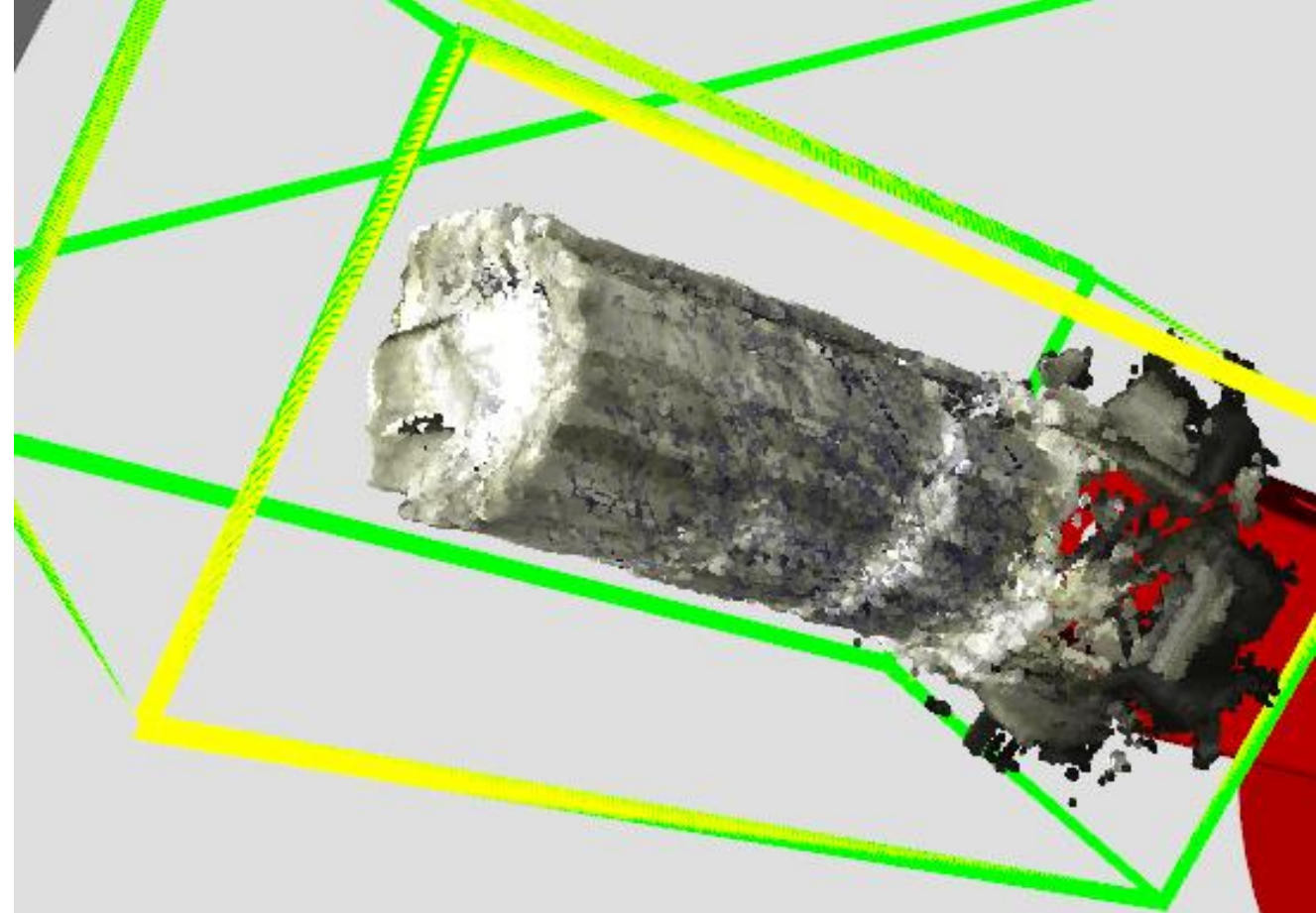
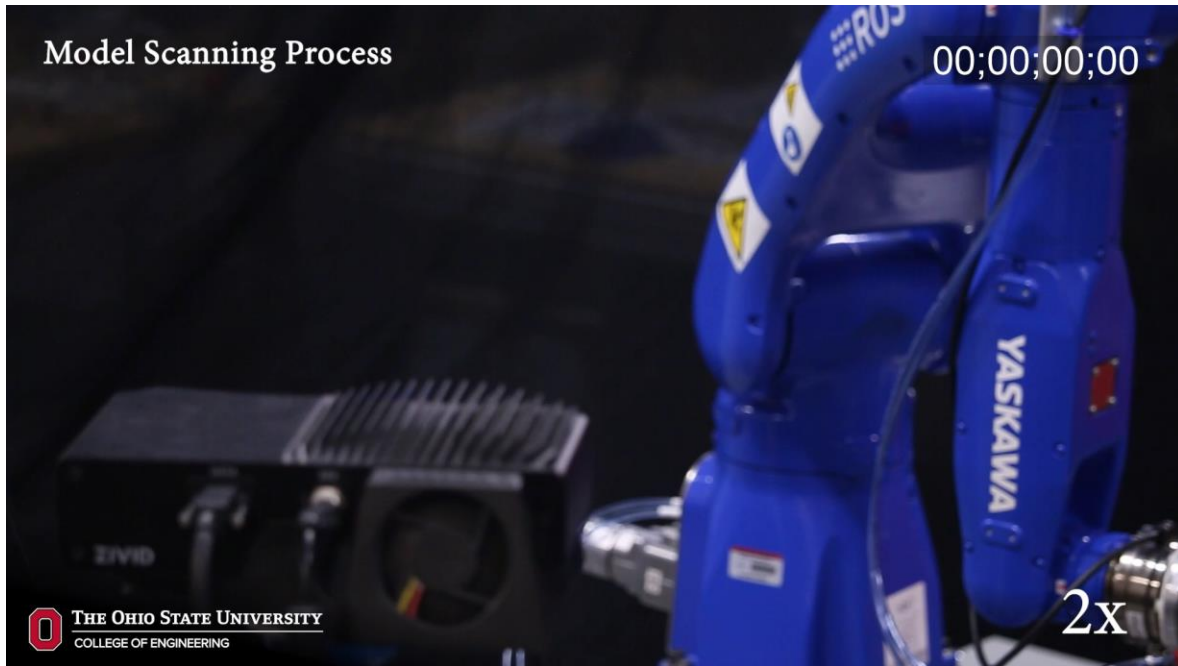




# Reconstruction

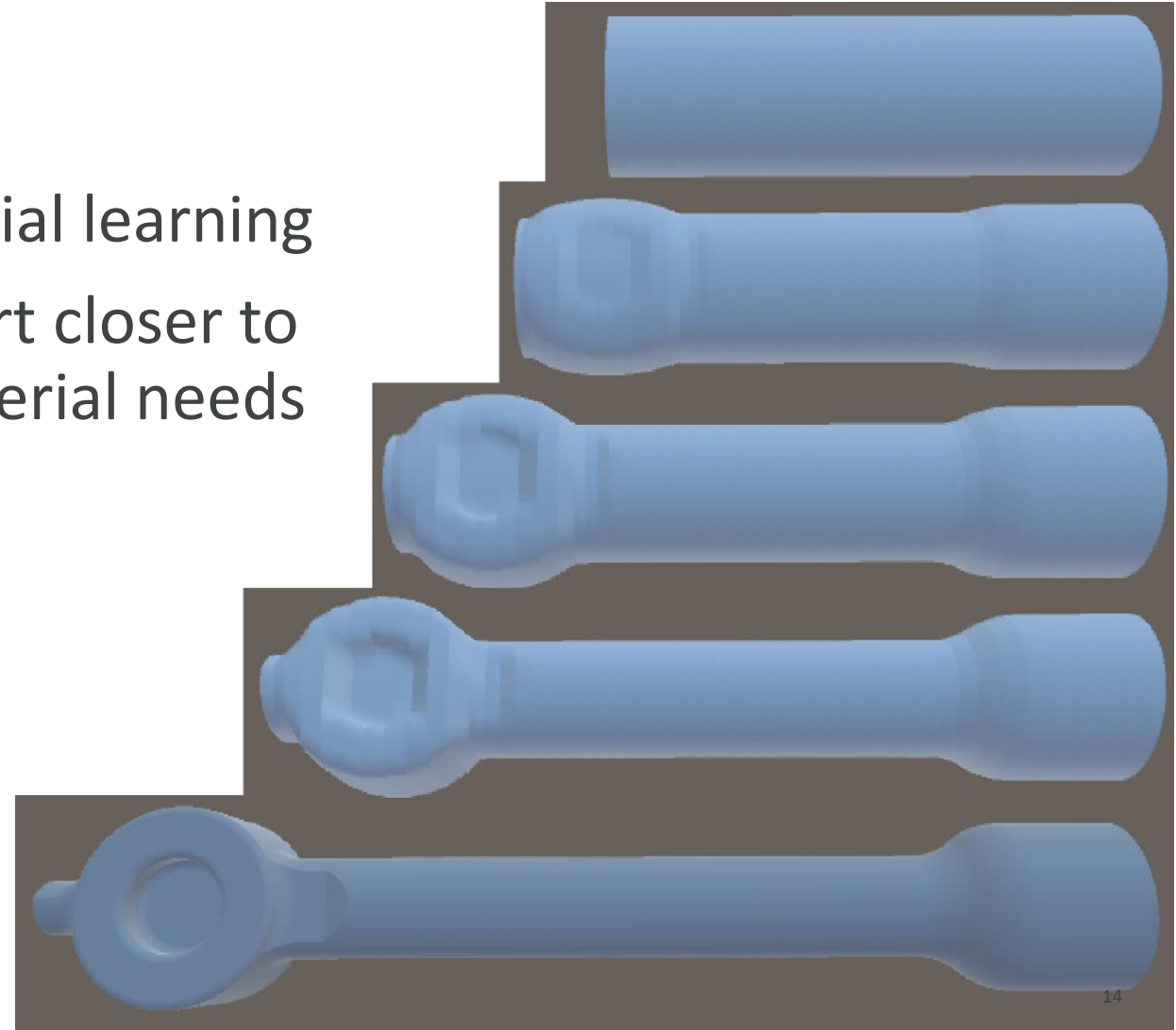
Model Scanning Process

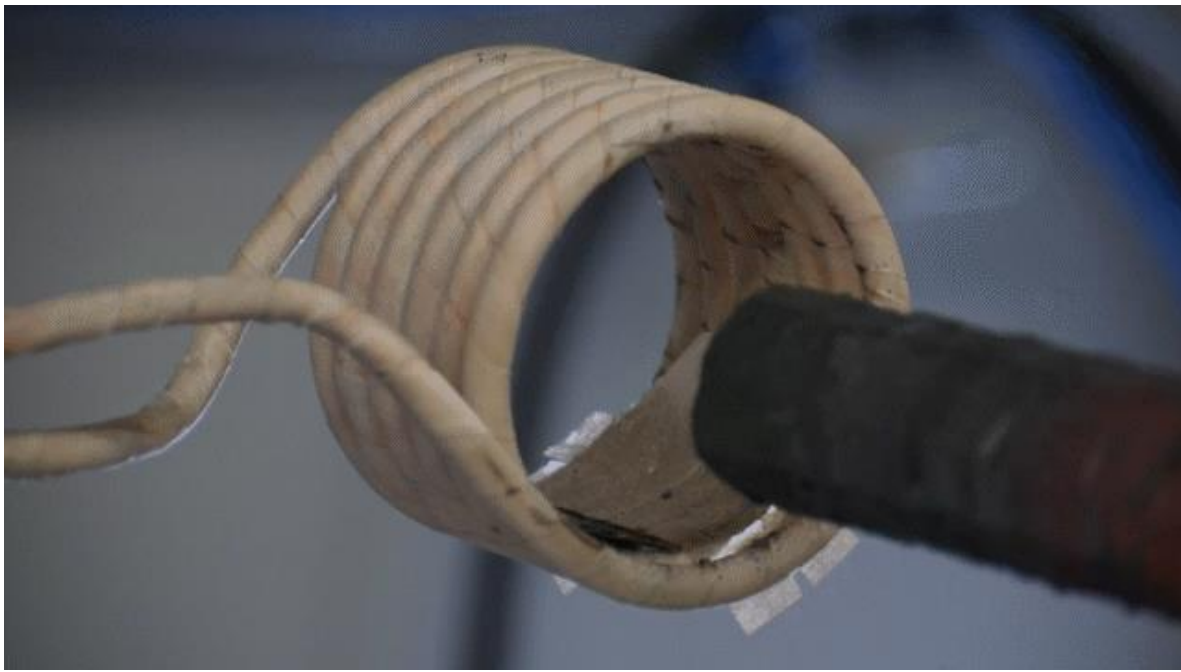
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# Progressive Guidance

- Human Heuristic guides experiential learning
- Cast preforms can be made to start closer to final net shape depending on material needs





## Technology Demonstration at Ohio State



**Total Forging Time: 1hr 4min**  
**Die: Dual 1.5" wide flats**

# Autonomous Robotic Painting

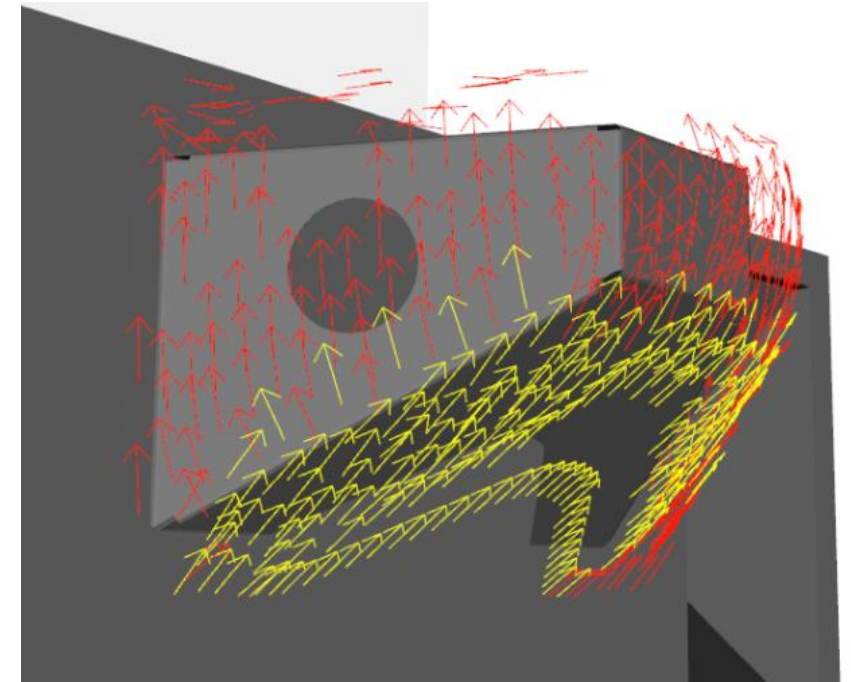


# Autonomous Robotic Painting

Robotic system designed to spray material at a precise thickness across user-defined surfaces.

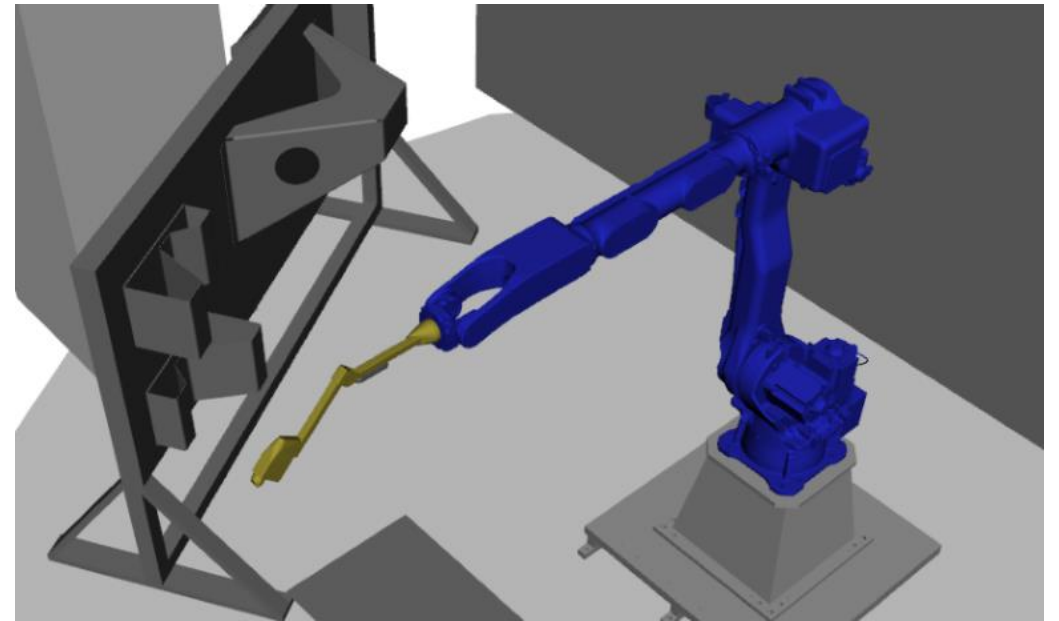
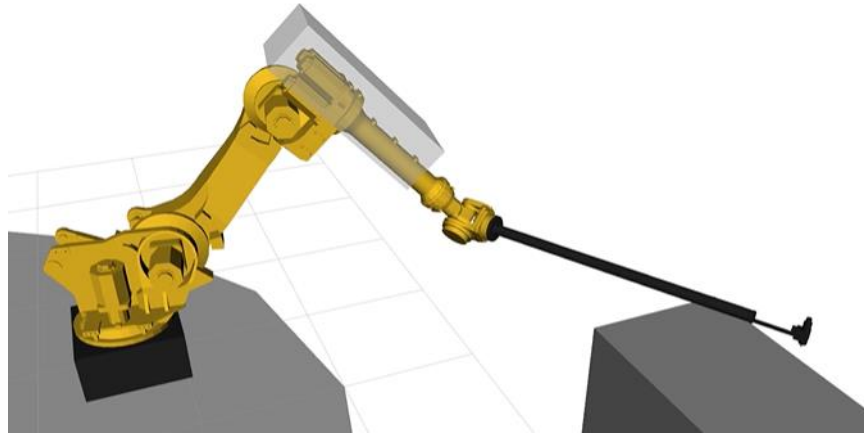
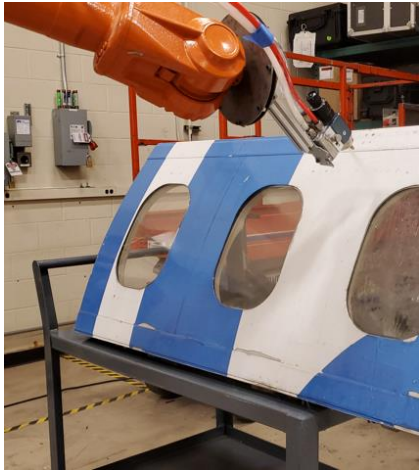
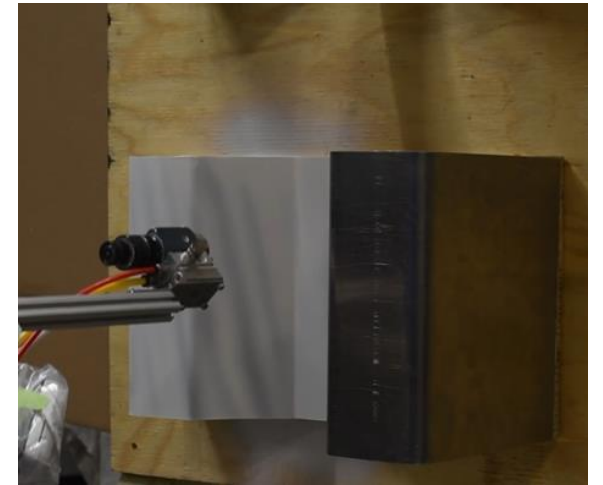
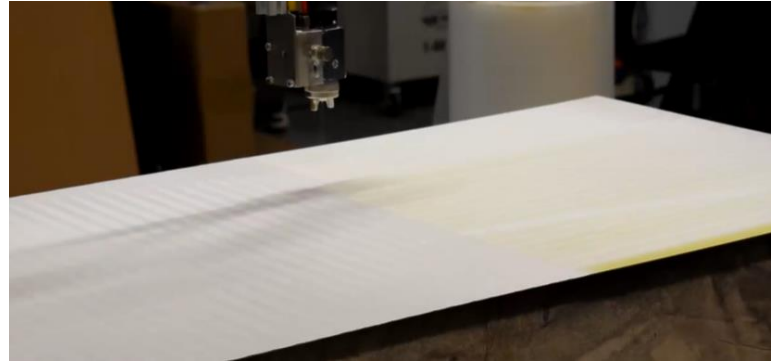
## *Key Technologies Developed:*

- User-defined paint thickness regions
- AI-driven surface path planning built on **Noether**
- CUDA GPU powered paint simulation model
- User Feedback and Interaction for process review



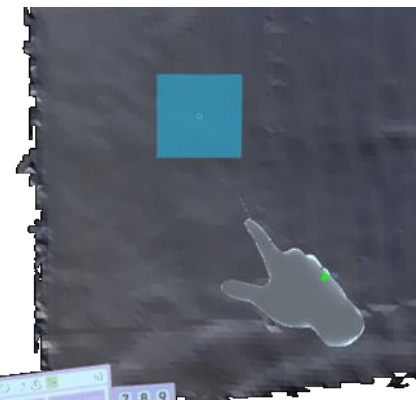
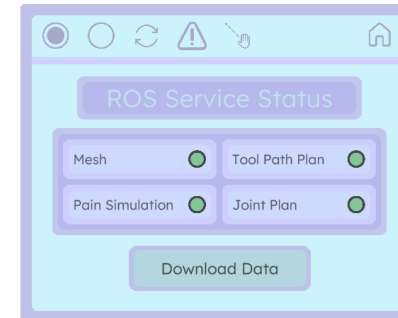
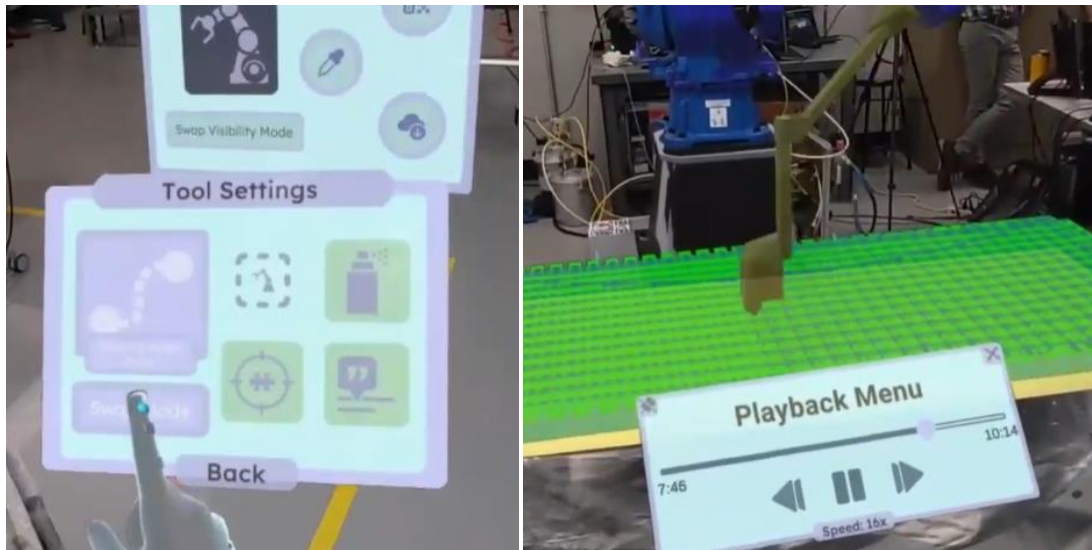
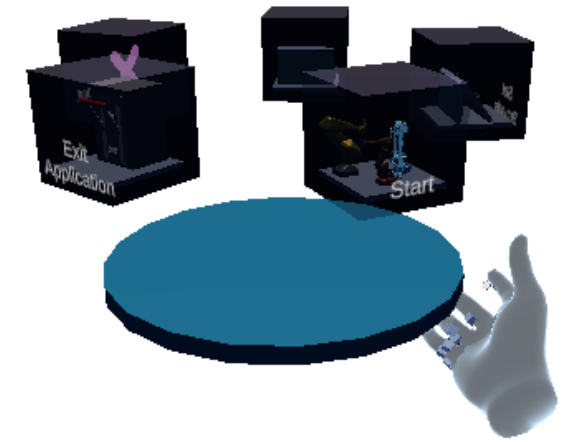
# ARP

- Hardware agnostic deployment
- Parameter-based spray calibration
- Motion Planning via Tesseract v0.18.1



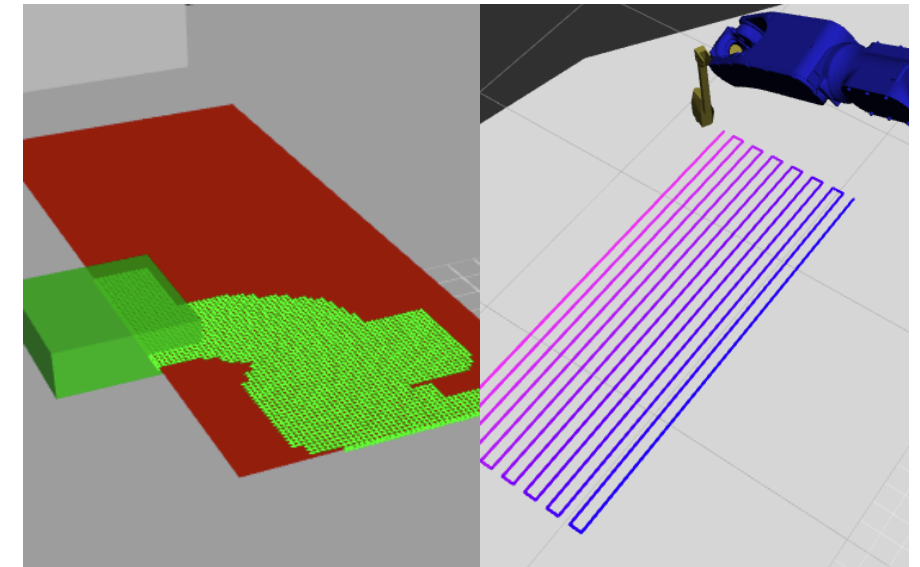
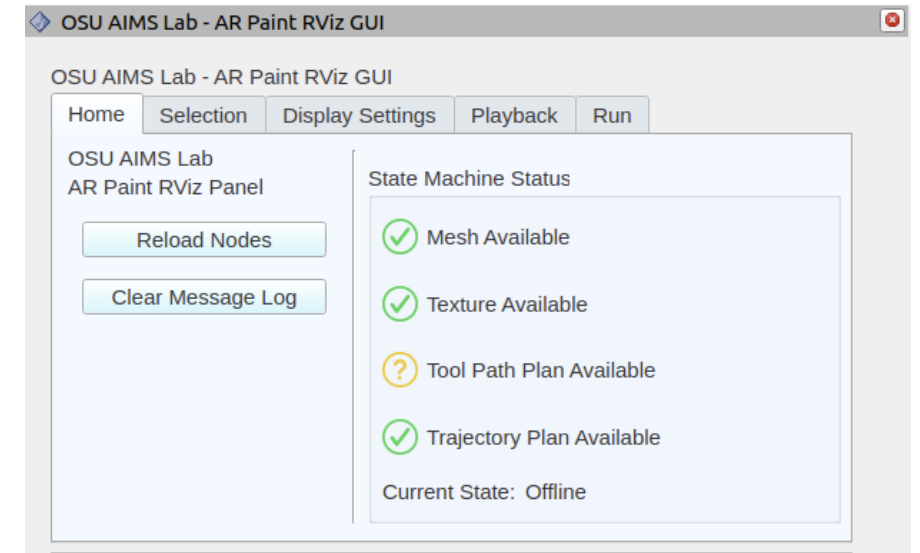
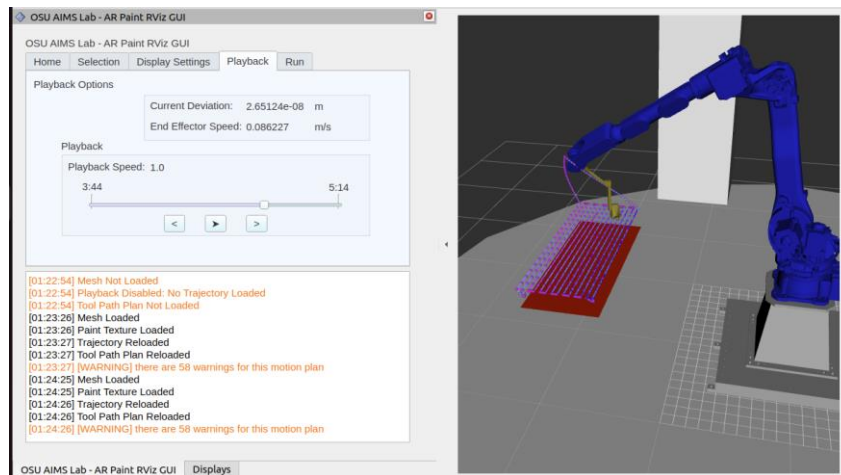
# UX via Augmented Reality

- HoloLens 2, Unity-based Environment
- ROS TCP-Endpoint Client-Server Model
- Minimal on-headset computation



# UX via RViz

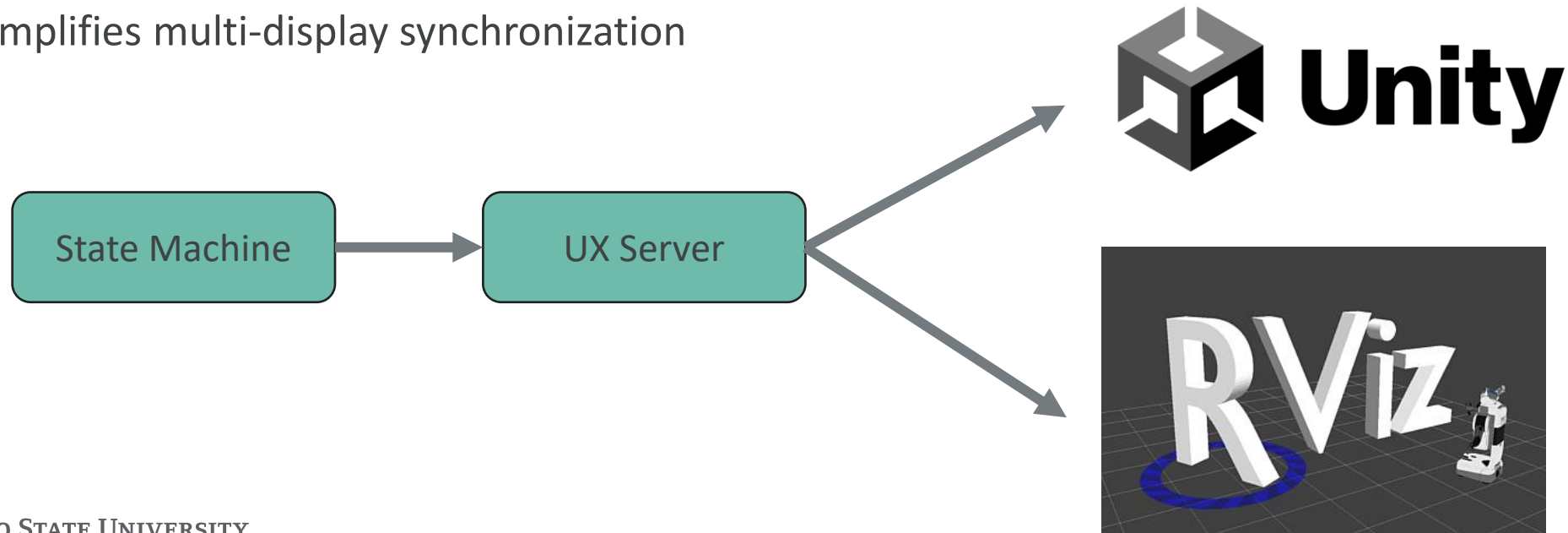
- Mesh region selection correlated to relevant tool path and trajectory segments
- Hardware control of paint delivery system
- Advanced Views,  
State Machine Status, Segment Manipulation, etc.





# UX. A Shared Back-End

- All display activity gathered and served from a dedicated node
- UX Server advertises multiple topics & services which viewports latch onto
- Reduces compute demand on display devices
- Simplifies multi-display synchronization



# Thank You

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