

FASTER AND ACCESSIBLE HUMAN ROBOT COLLABORATION RESEARCH USING XR TECHNOLOGY

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Introduction

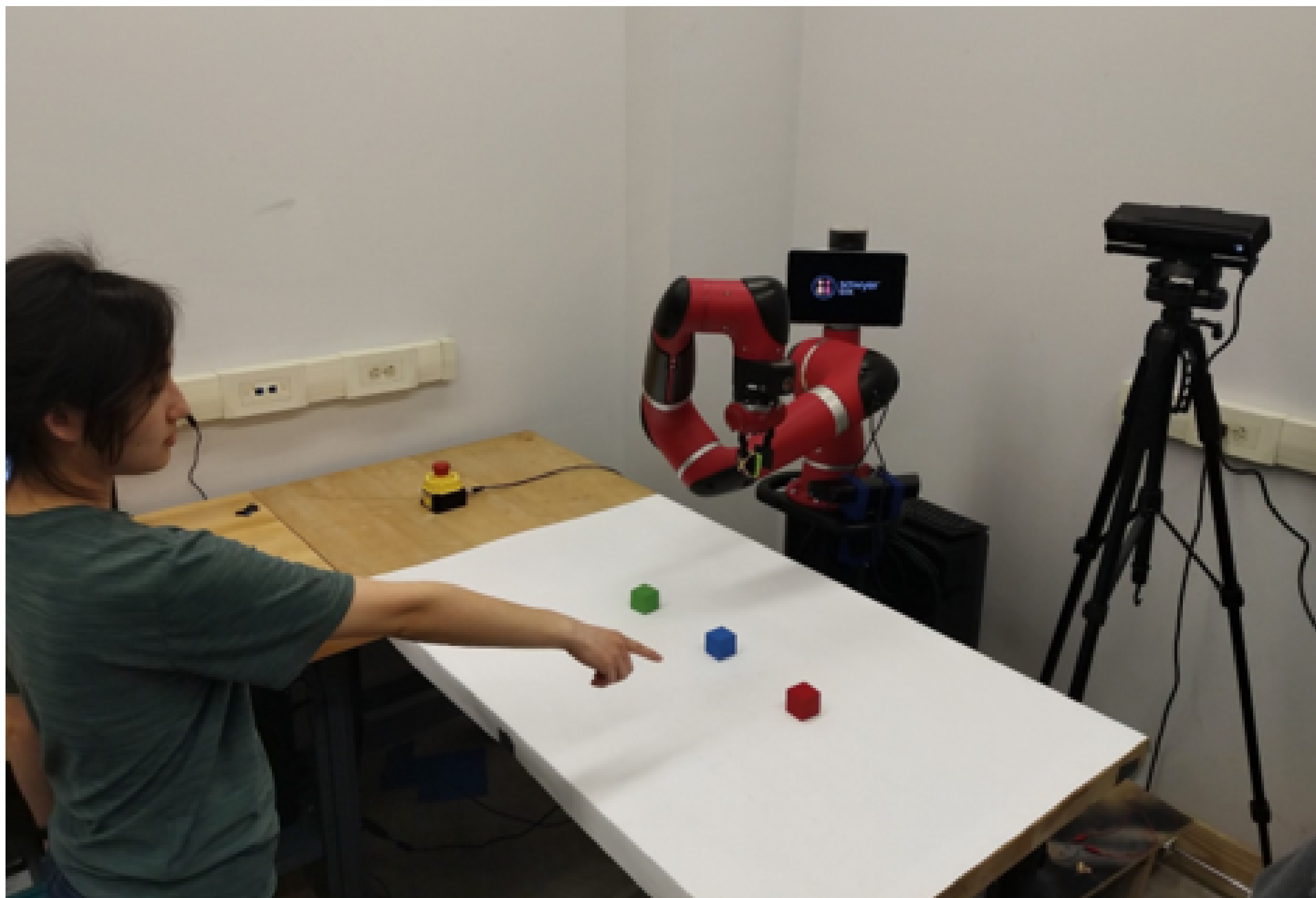
Is it feasible to use current XR Technologies to create a simulated Human Robot Collaboration environment?

XR Extended Reality: Umbrella term for Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)

HRC Human Robot Collaboration: The research field of joint operation of robots and humans with a common objective

Blocks World

Existing HRC Research Lab Demo



- Artificial Intelligence Planning Domain
- Abstract Model for 'Recognition > Planning > Interaction' Tasks
- Modified for HRC Applications: Natural Directions and Feedback (Pointing and Talking), Adaptive Subtask Assignment

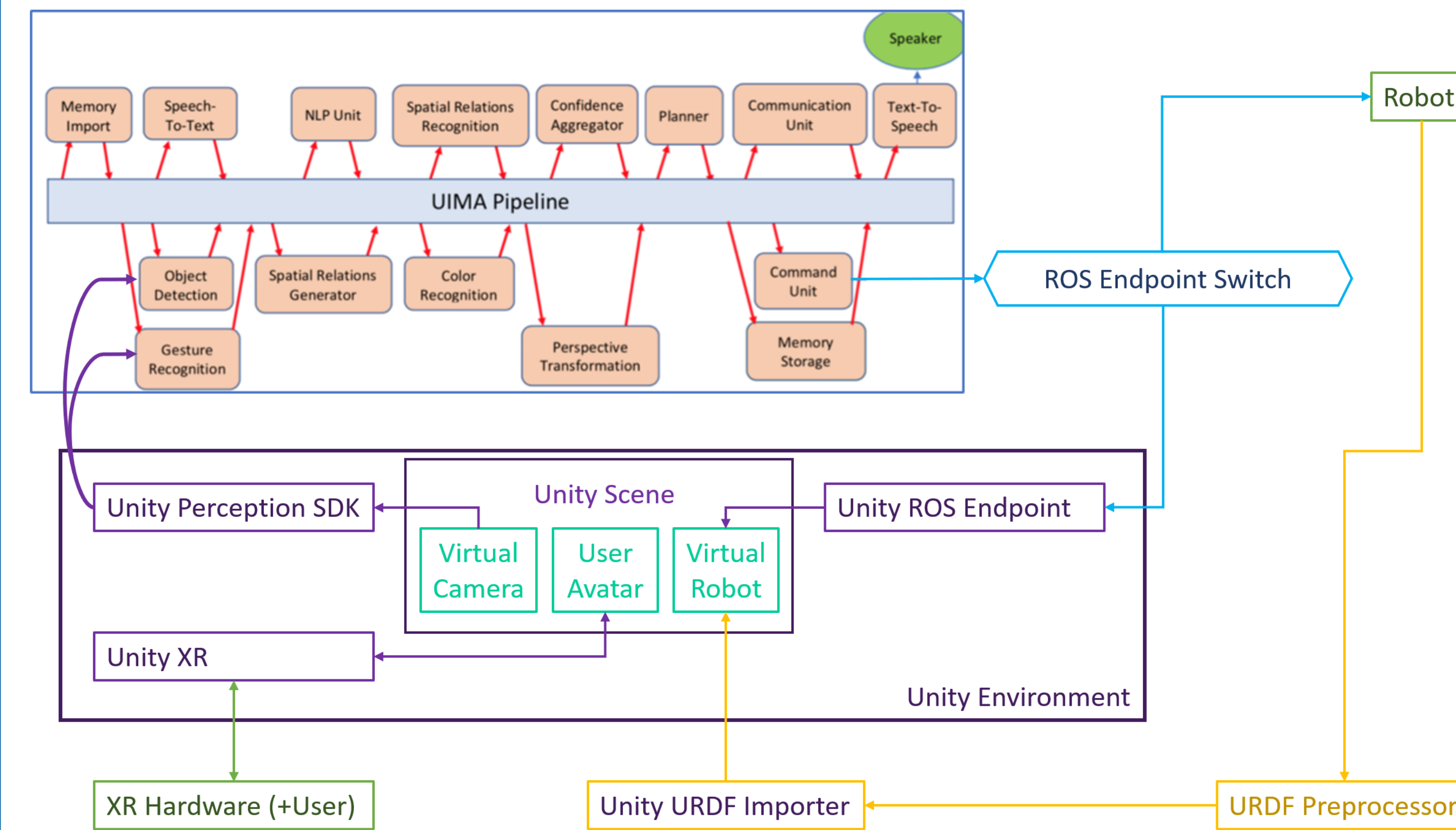
The Vision

Simulation-driven Research & Prototyping of HRC Systems

- Accessible to Researchers, Students and Hobbyists
- Real-time, Zero-risk Interactive Testing Scenarios
- Rapid Iteration through Software and Virtualized Hardware
- Distributed, Collaborative Projects sharing Virtual Labs
- Interoperability with cutting-edge AI Projects in adjacent fields (e.g. Machine Vision, Autonomous Driving)

Architecture

Extended Architecture to attach the existing Control System to the Unity Simulation Environment



UIMA Unstructured Information Management Application (Apache Data Processing Framework)

URDF Universal Robot Description Format (Exchange Format for Robot Definitions)

ROS Robot Operating System (Open-Source Robotics Middleware Suite)

Unity

Serves as the Platform/Central Hub for the Simulated Lab Environment

- Highly Extensible Game Engine with support for Simulation Applications
- Already in use for Machine Vision and Autonomous Driving Research, Industrial Process Simulation
- Physics Engine supports Temporal Gauss Seidel Solver for higher Simulation Accuracy
- Integrates robust XR Platform and Hardware Support (e.g. SteamVR, Windows Mixed Reality, Oculus/Meta SDK)
- Allows Integration of Remote Components and Distributed Data Processing
- Long Term Support and substantial Asset Ecosystem future-proof Prototypes for further Development

Acknowledgements

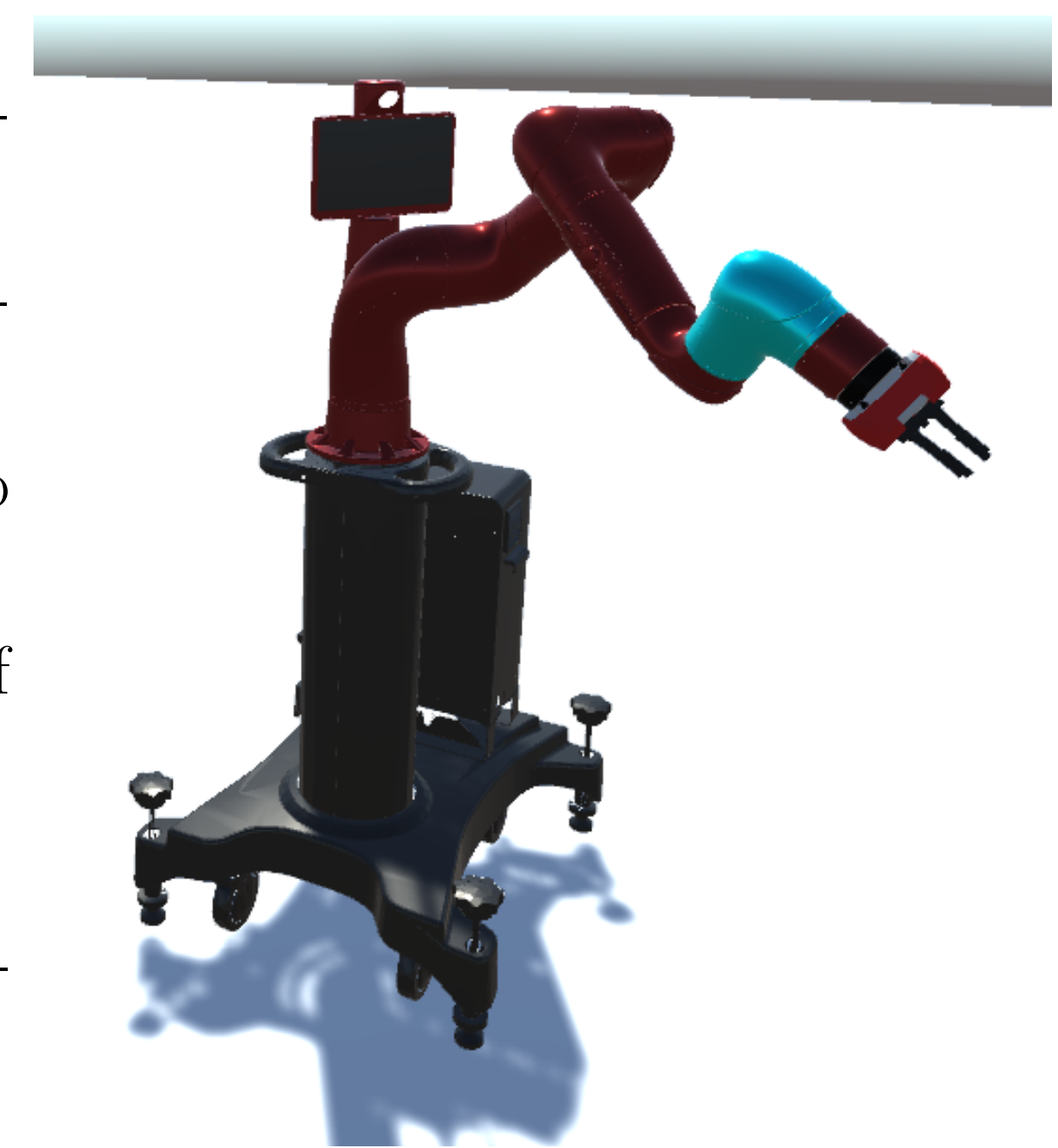
Dr. Michael Wollowski - Project and Thesis Advisor, HRC Lab Lead

RHIT HRC Lab: Neelie Shah, Lilin Chen, Xiangnan Chen, Yifan Cui, Joseph Knierman, Xusheng Liu, Tyler Bath, Sophie Brusniak, Michael Crowell, Sheng Dong, Joseph Knierman, Walt Panfil, Sooyoung Park, Mitchell Schmidt, Adit Suvarna

Progress

Prototypes & Tech Demos

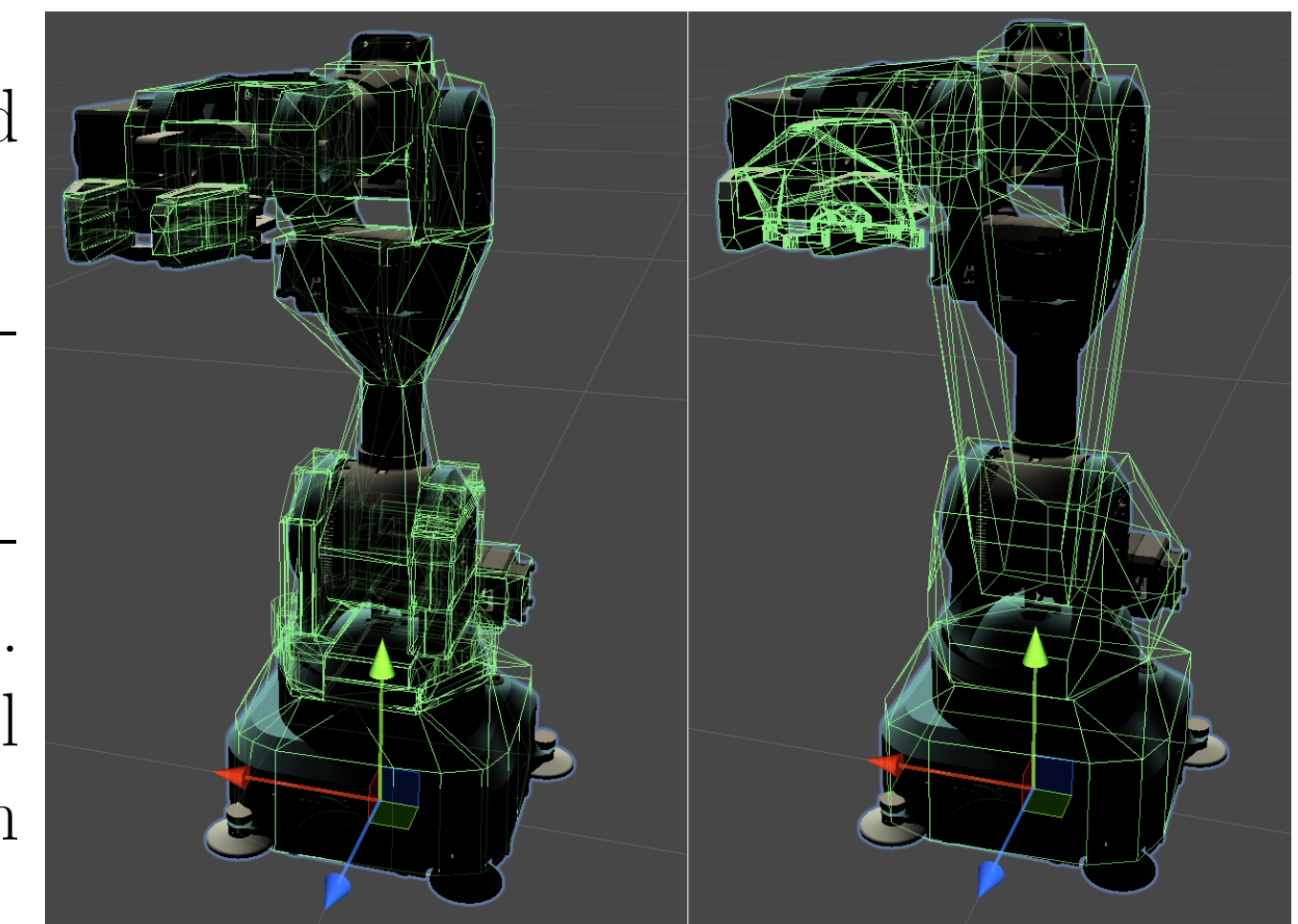
- Core Pipeline functional via Developer Mode
- Workable Components and Tooling for independent steps
- Operational Virtual Twin of Lab Robot in Demo Mode
- Workflow outline for integration of new/updated Robots
- Containerized ROS environments
- Mostly "Plug & Play" Unity XR related Components



Limitations

Uncharted Grounds

- Lacking Maturity of involved Frameworks and Tools
- No first-party Validation of Interoperability
- Different constraints and standards between ecosystems (e.g. Requirement of Convex Hull Colliders in Unity; Comparison to the right)



Fundamental Limitations

- Focus on Real-time Operation, Accessibility and Iteration Rate
- Revalidation of Results required before Real-world Application
- Not suitable for Safety Certifications

Outlook

Maturity of underlying Technologies is improving rapidly

- Industry 4.0 push increases HRC Interest
 - Autonomous Vehicle Research strongly pursues Simulation Approaches
 - Unity and Industry heavily invest in Simulation-focused Development
 - COVID-19 has increased demand for Distributed & Remote Research
- XR-backed HRC Simulation is Feasible, but will require continuous Attention and Commitment from Technology Providers and Researchers*