

DataRealm



Standardizing Humanoid Control

Lessons from Industrial Robotics

DataRealm Inc. | Humanoid Application Lab

HumanoidAppLab.com

Table of Contents

1. About Us
2. Humanoids of Today
3. Working with Humanoids
4. Lessons from Industrial Robotics
5. How we should work with Humanoids

About Us

- Roboticist on the Humanoid Application Lab team at DataRealm
- PhD in Computer Science at the University of Windsor
- Focus on simulations, digital twins, and robotics
- SRice@DataRealmInc.com





Humanoids of Today

1. Hardware
2. Software
3. Artificial Intelligence

Humanoids of Today – Hardware



Humanoids of Today – Hardware

- Couldn’t be any more varied!
- Wheeled versus legged
    - Different types of wheels and drivetrains
- Different body axes
- Different arm sizes, degrees-of-freedom, reach
- Different proportions
- Different sensors
    - Type, position, number, quality

Humanoids of Today – Software



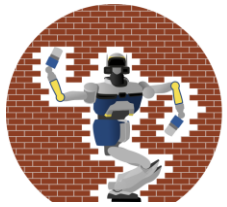




- Even more varied than the hardware!
- Most run on a version of Robot Operating System 2 (ROS 2)
  - Difficult compactivity across versions and operating systems
  - Various extensions and addons which each add more complexity and compatibility issues

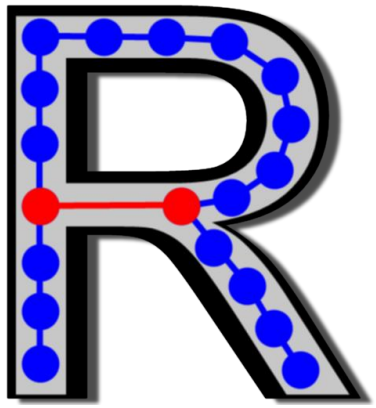


- Same problem, multitude of solutions
  - Motion planning: MoveIt, cuMotion, Pinocchio, RoboPlan, Tesseract
    - Within MoveIt, what solver to use: KDL, TRAC-IK, IKFast, Pick-Ik
  - Navigation: Nav2, cuVSLAM, ORB-SLAM3, RTAB-Map
    - Usually no one does everything
    - Need to combine aspects of a few













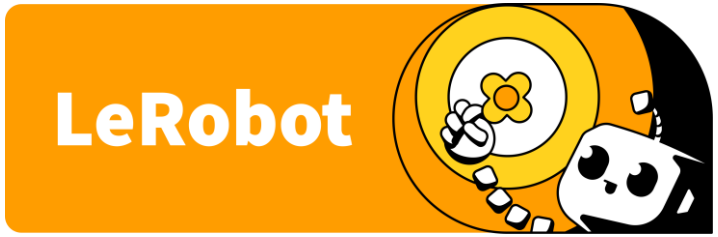
  - Vision systems, audio listening and playback, text-to-speech, HMIs

Humanoids of Today – Artificial Intelligence



Isaac GROOT

- Chaotic!
- RL versus VLAs versus VLMs versus WFMs?
  - Using multiple methods together?
    - How can we integrate “non-AI” control logic?
- Standalone or in conjunction with other AI or control methods?
  - Vision systems
  - Manipulation
- Data collection, training, and deployment?
  - Local versus remote API?
- What hardware and software each support?
  - What is available out-of-the-box versus needing to integrate?





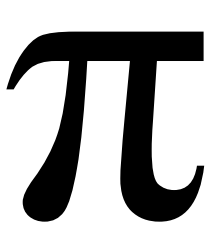
SKILD AI

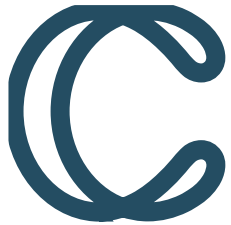


Dream Labs



Gemini





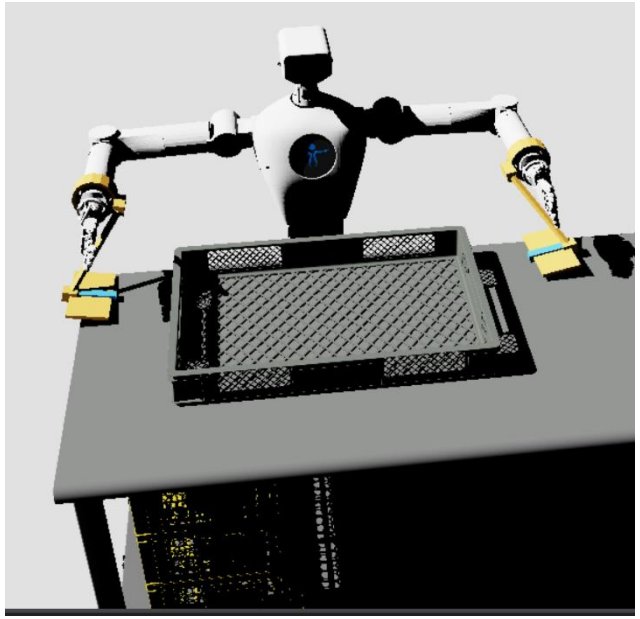


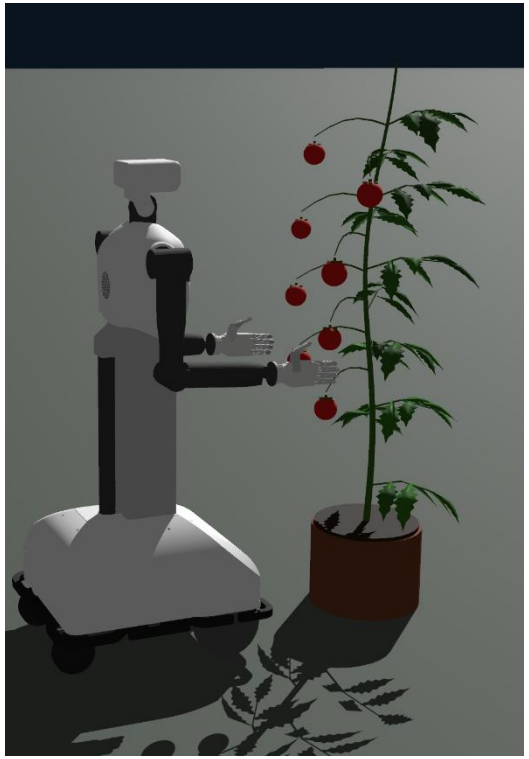
OpenAI

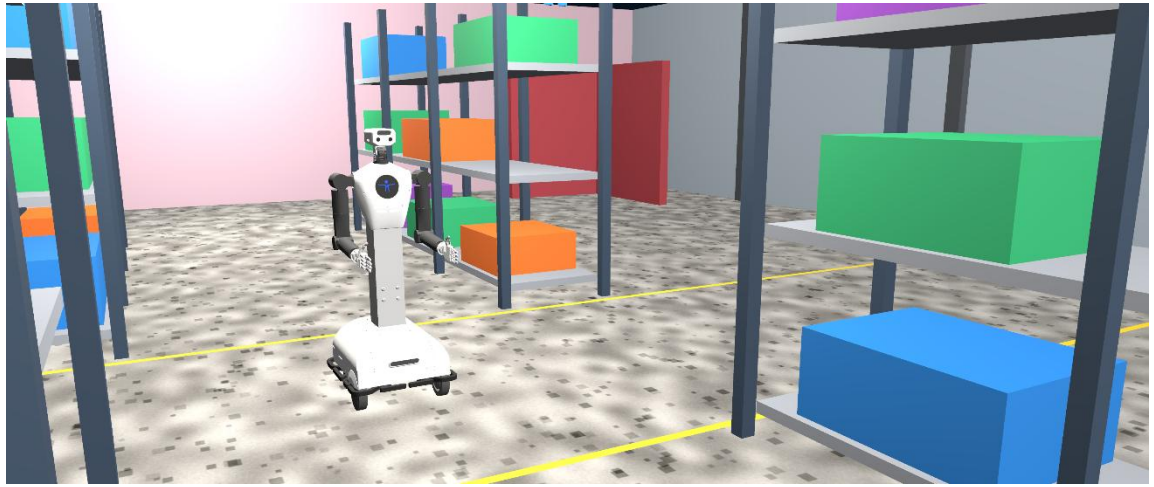
ANTHROP\C

Humanoids of Today – Artificial Intelligence

- Why do we need AI anyways?
  - Tasks we are looking to assign humanoids to are far more complex than most other robotics and automation tasks
    - Requires more advanced reasoning skills









Working with Humanoids

1. Collect data
2. Train AI on the data
3. Deploy the trained AI on the robot
    - In simulation first for validation





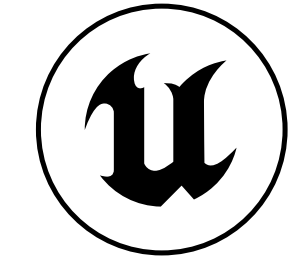














Working with Humanoids



Working with Humanoids

1. Collect data*
2. Train AI on the data**
3. Deploy the trained AI on the robot***
    - In simulation first for validation****
4. Repeat for new tasks, robots, or accounting for failures in the previous training and deployment*****

*If a framework exists to capture robot state into a dataset and the data is compatible with your AI trainer

**If the humanoid you're working with is supported

***If you have the infrastructure or compatible API with reliable networking to deploy it

****If your robot's control stack while running AI is compatible with a simulation engine and your hardware can run it

*****Can we continue training or do we need to start over?

Working with Humanoids

- How often do we think those all align?



Working with Humanoids



Integration Code

HMI

Behaviors

AI Training and Deployment

PLC







NVIDIA

ISAAC

Working with Humanoids



Integration Code

HMI

Behaviors

AI Training and Deployment

Public API





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HMI

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Public API



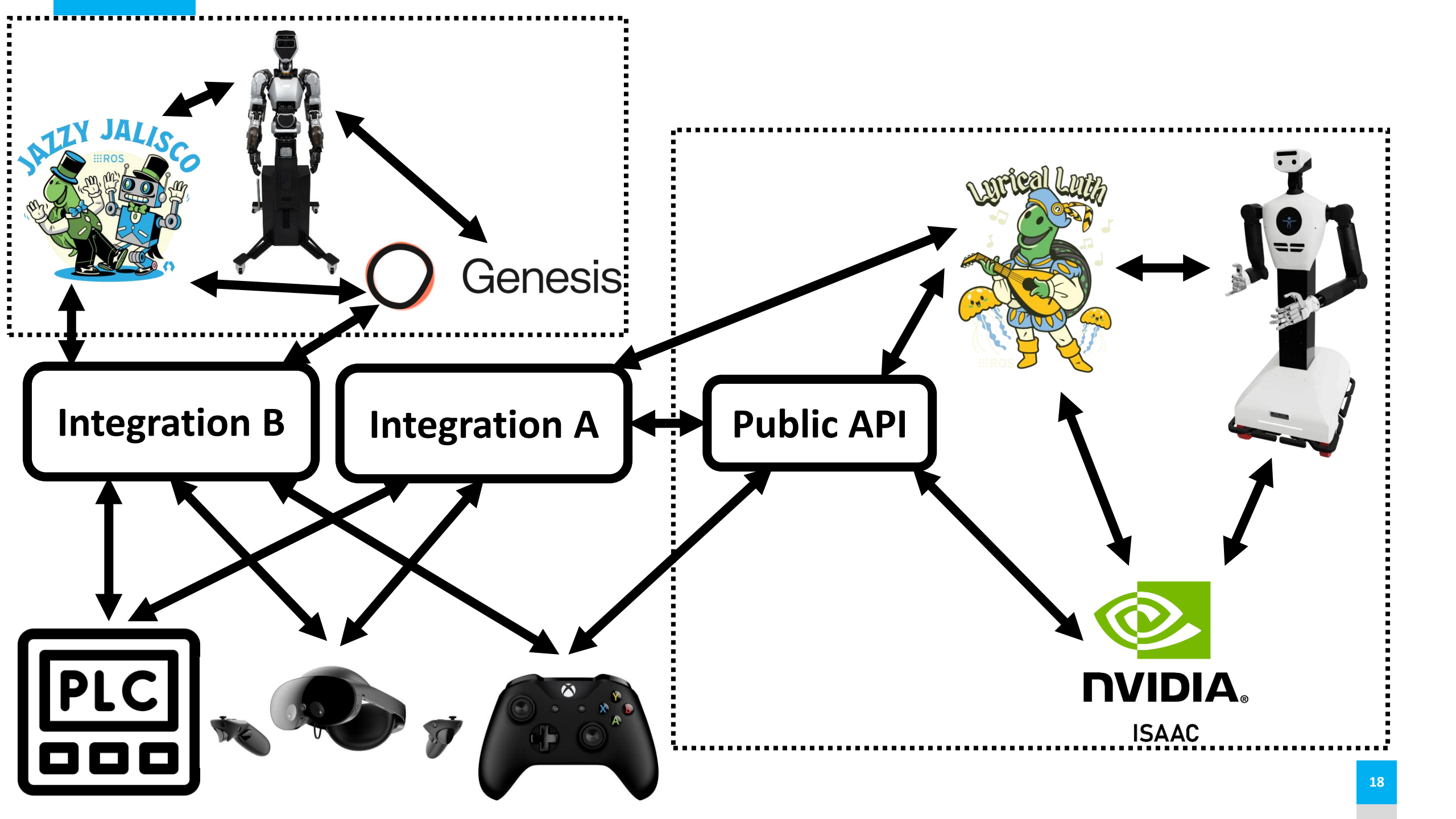


PLC



NVIDIA

ISAAC


JAZZY JALISCO
ROS
Genesis
Integration B
Integration A
Public API
Lyrical Luth
PLC
NVIDIA
ISAAC

Working with Humanoids

- Fragmented and duplicated logic
- Similar looking robots can have drastically different code to hook into; extreme divergence in your code
  - Arms inverse kinematics versus forward kinematics
  - Pressure sensors versus torque readings versus nothing
  - Hand size, shape, fingers, joints, etc.
- Forced to take on the gap between the research labs and practical integration
- Development and experience using tools and technologies typically not common place in industry
  - Often poor documentation (if any) and ever-changing and emerging tools
- “Surely if I just focus on the ‘big players’, these problems and workload will be reduced!”

Working with Humanoids

- Unitree currently officially supports Ubuntu 20.04
  - Support ended May 2025

README BSD-3-Clause license

unitree_sdk2

Unitree robot sdk version 2.

Prebuild environment

- OS (Ubuntu 20.04 LTS)
- CPU (aarch64 and x86_64)
- Compiler (gcc version 9.4.0)



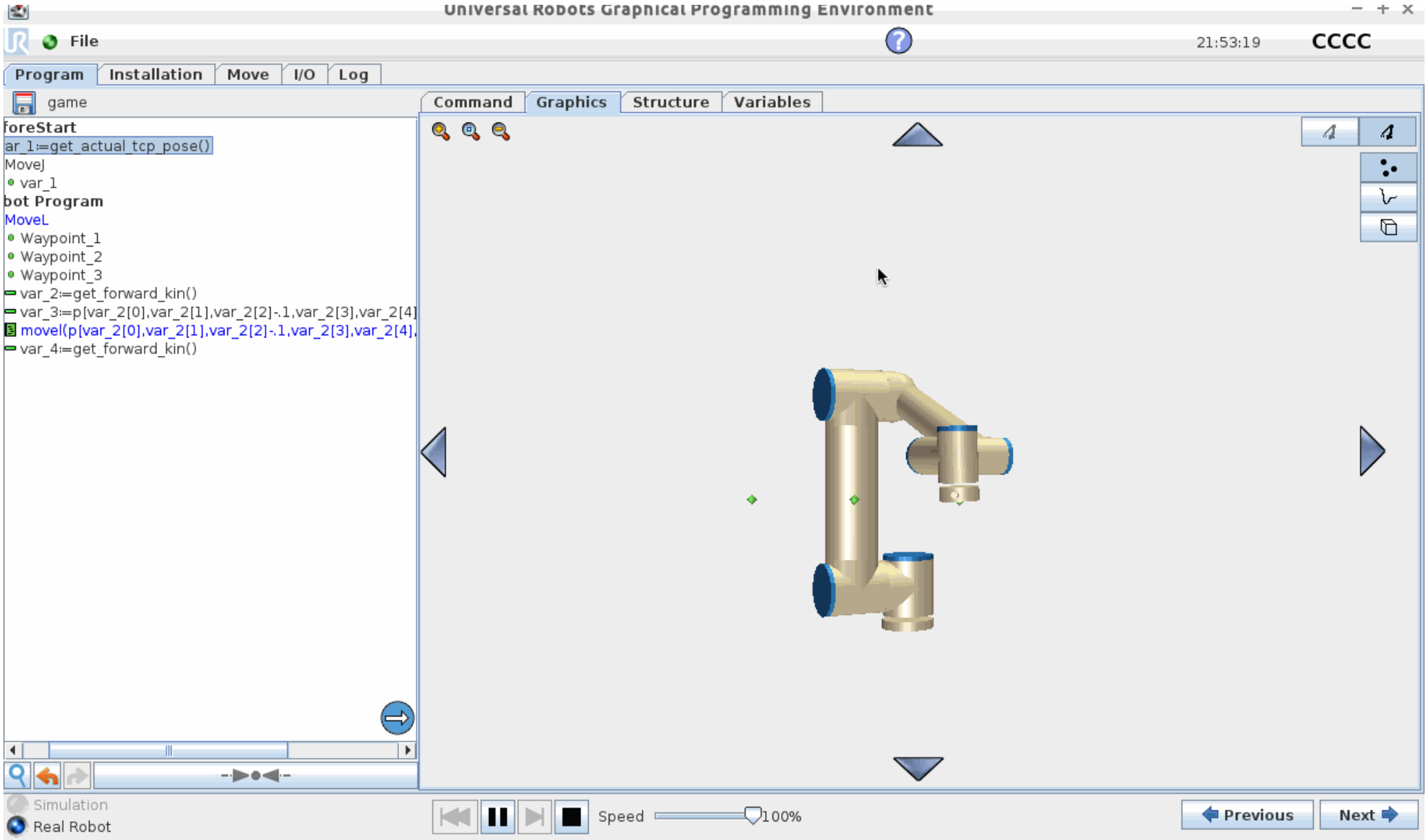


Lessons from Industrial Robotics

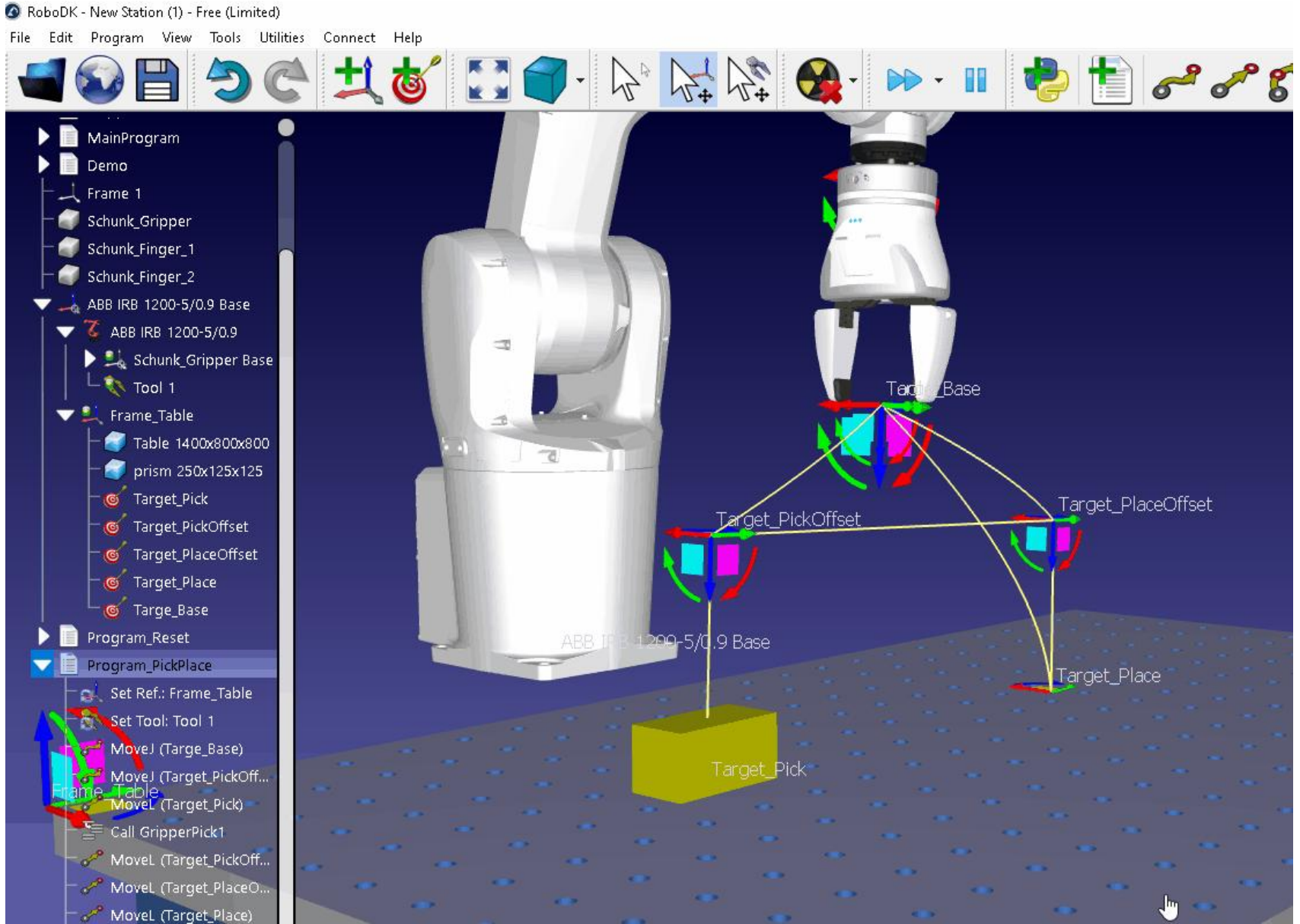
- Super common place because they are easy to integrate
- While slight differences, all have converged
  - Reach a target position and orientation
  - Linearly move in a smooth motion
  - Allow for tooling offsets in movement calculations



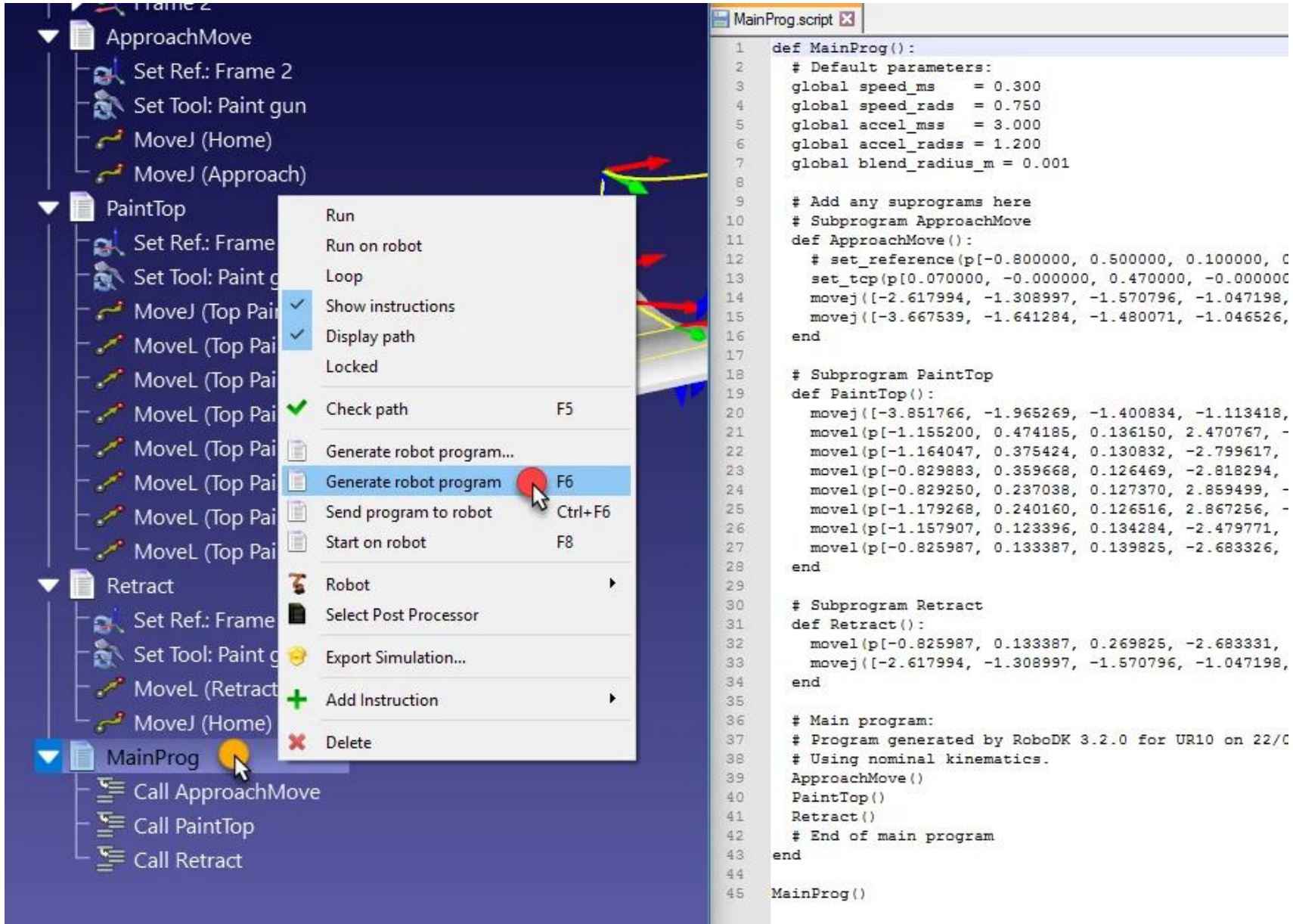
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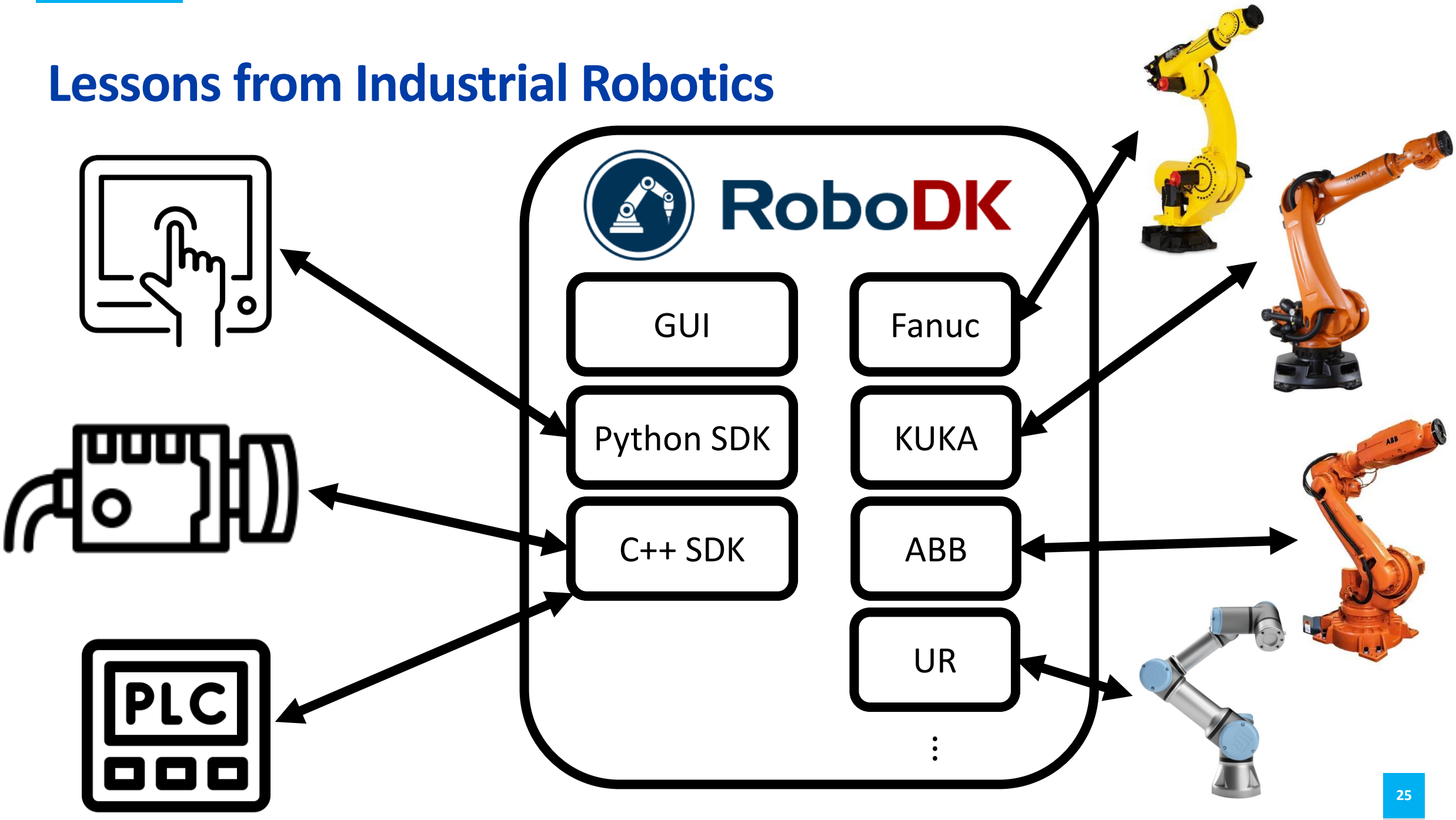
Lessons from Industrial Robotics



Lessons from Industrial Robotics



Lessons from Industrial Robotics



Lessons from Industrial Robotics

- Streamlined development and deployment
- Easily swap arms or even brands
- Easily integrate other hardware and software into your control programs



How we should work with Humanoids

- Copy what we can from industrial arms
- Some aspects are hard to standardize
  - Support what we can and expose or disable certain APIs per robot
  - Uncertain how hardware will evolve over the next few years



How we should work with Humanoids

- LeRobot is the closest to this
  - Supports some VLAs, WFMs, and RL options
  - Supports a few robots and humanoids, with ability to integrate new ones
  - Has a helper dashboard to streamline data collection and inference

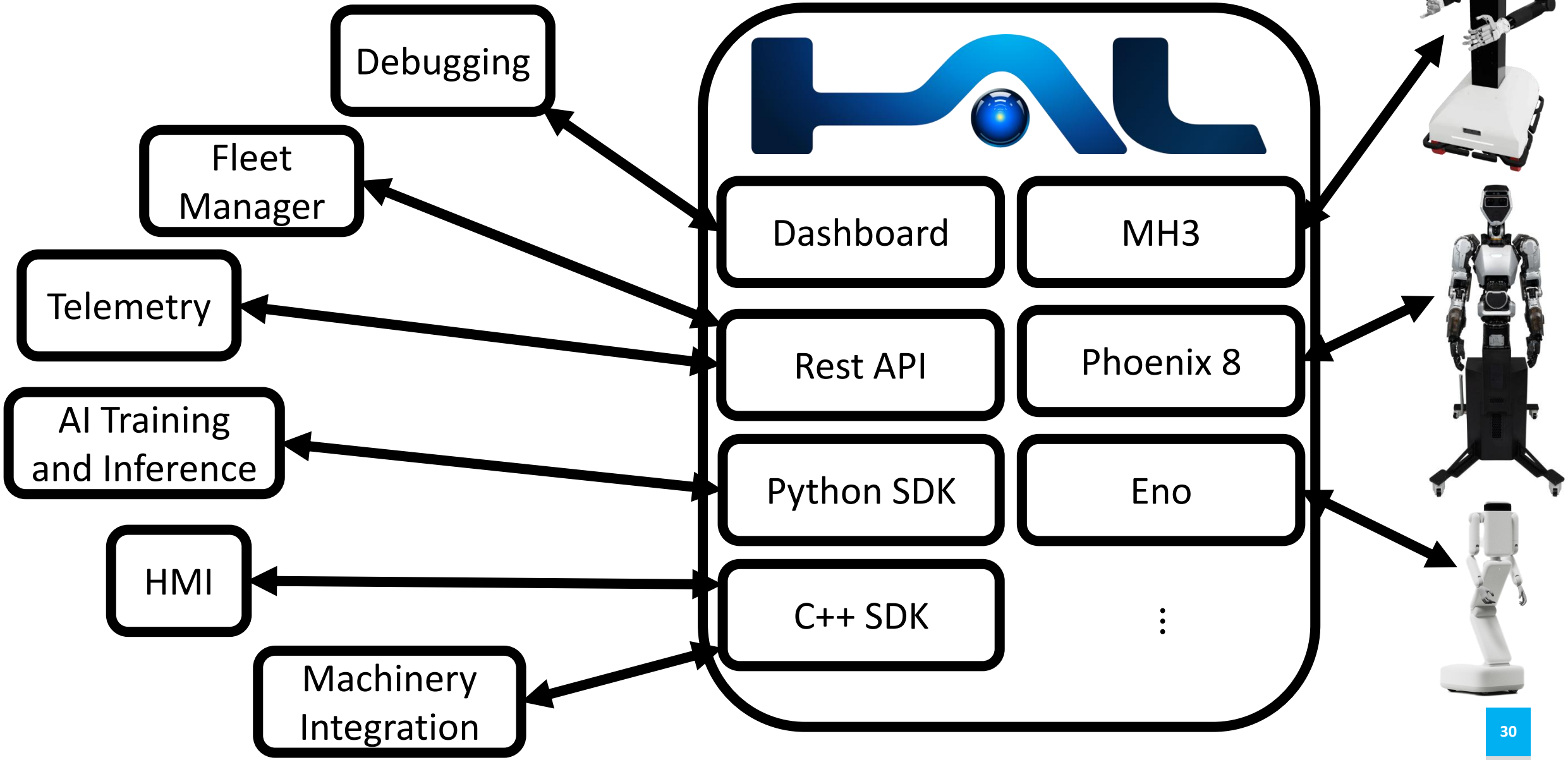


How we should work with Humanoids

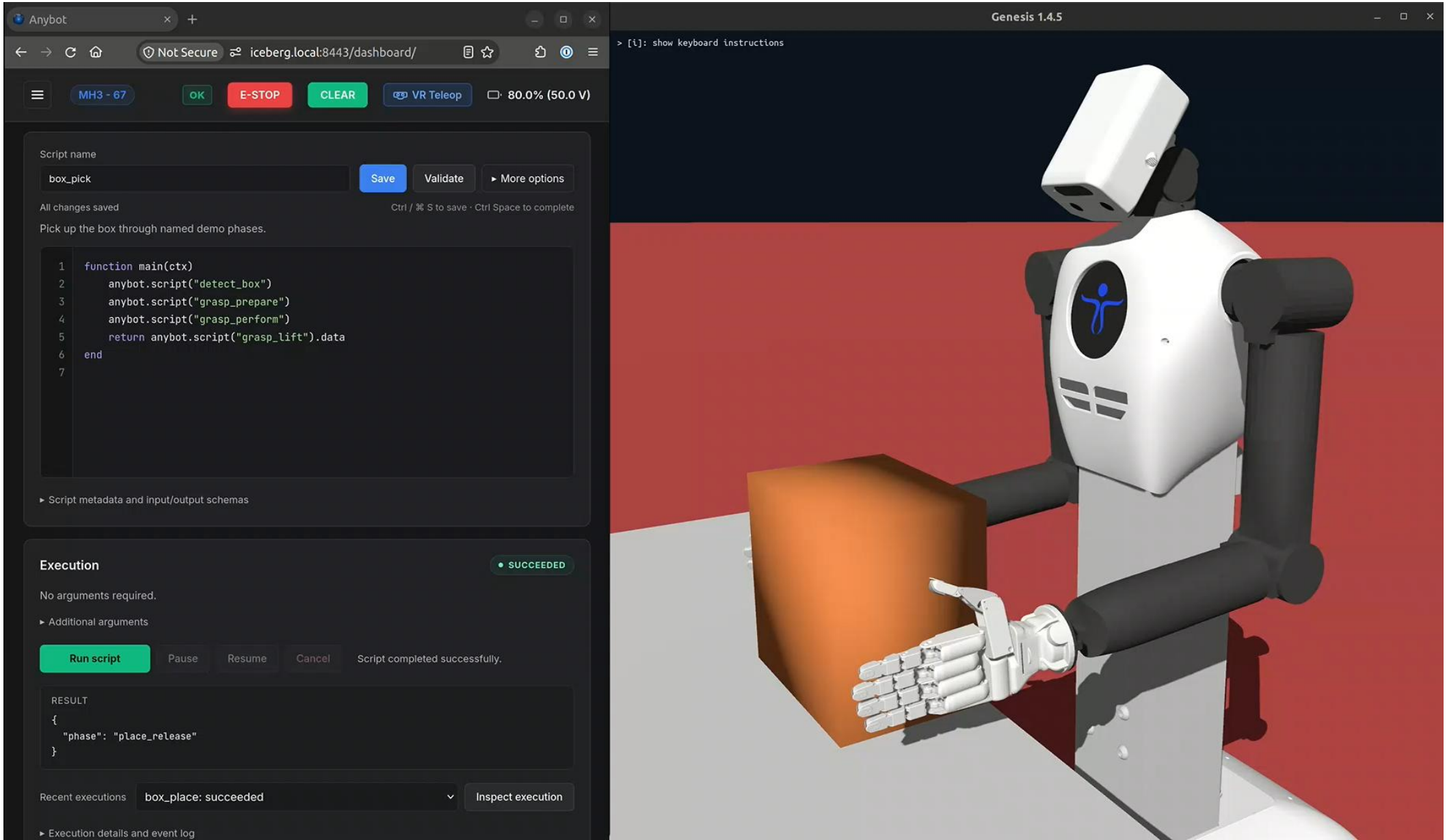
- LeRobot is only a piece of the puzzle
  - Python
  - Limited official support
  - Purely focused on Machine Learning methods



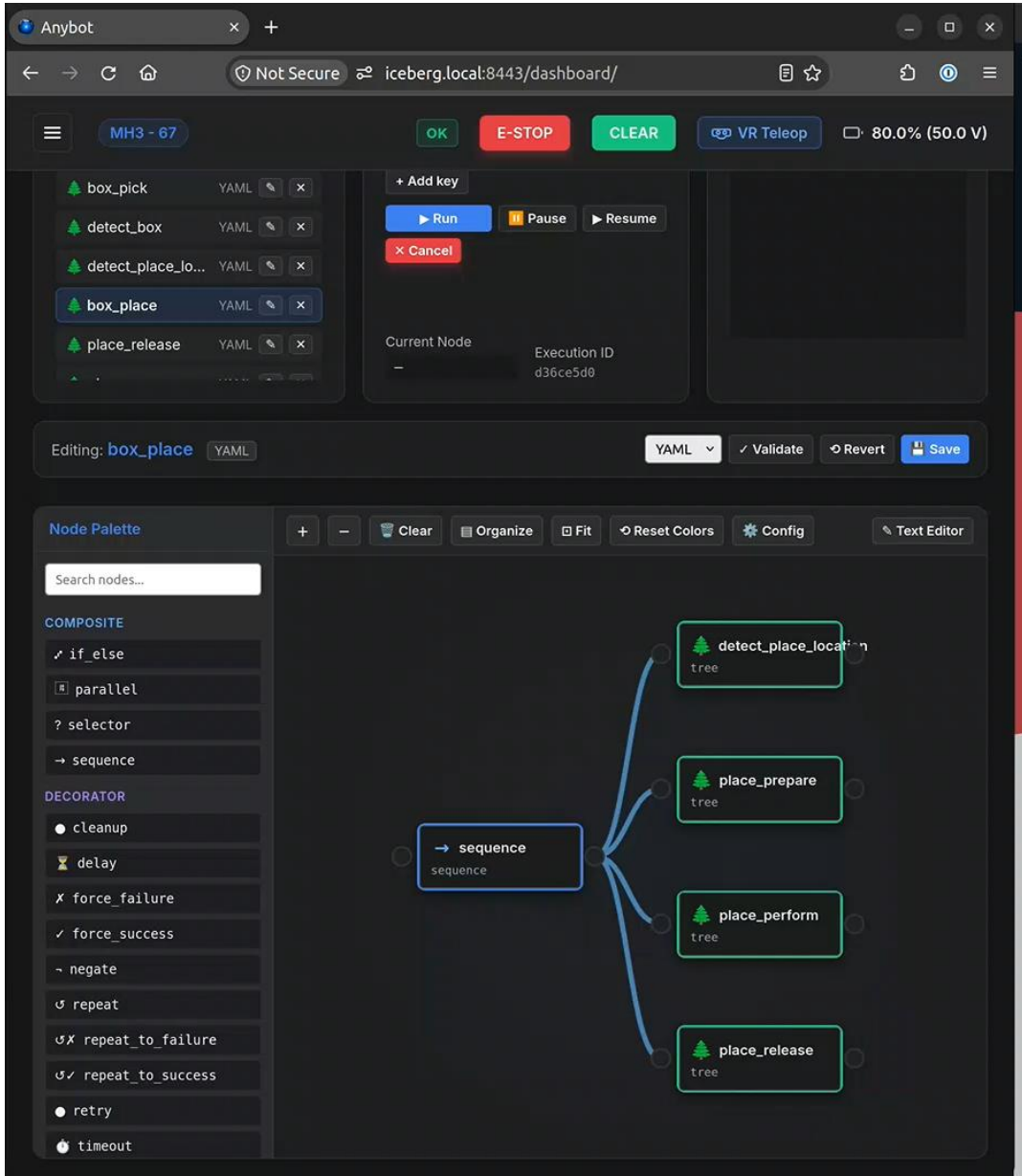
How we should work with Humanoids

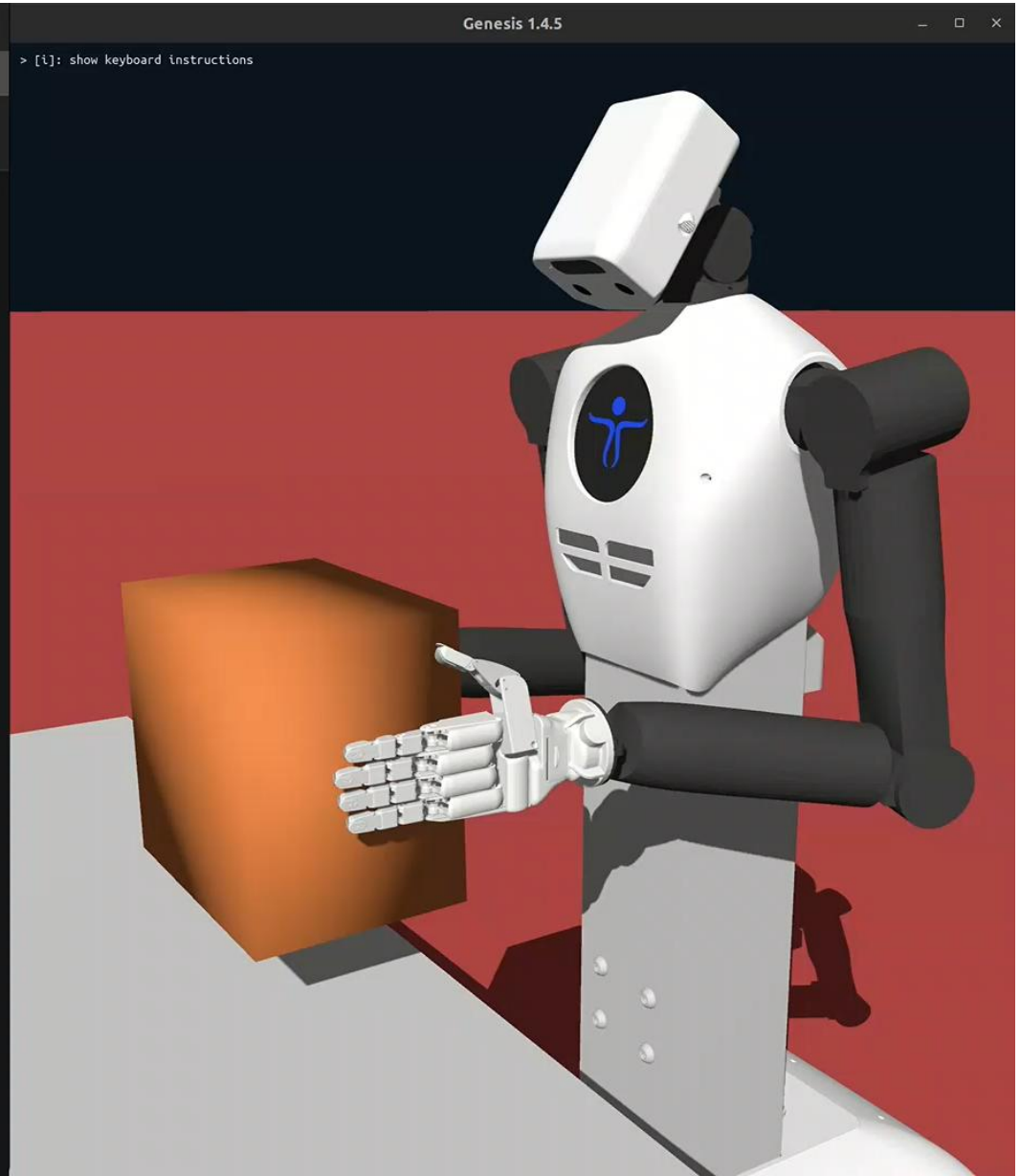


How we should work with Humanoids

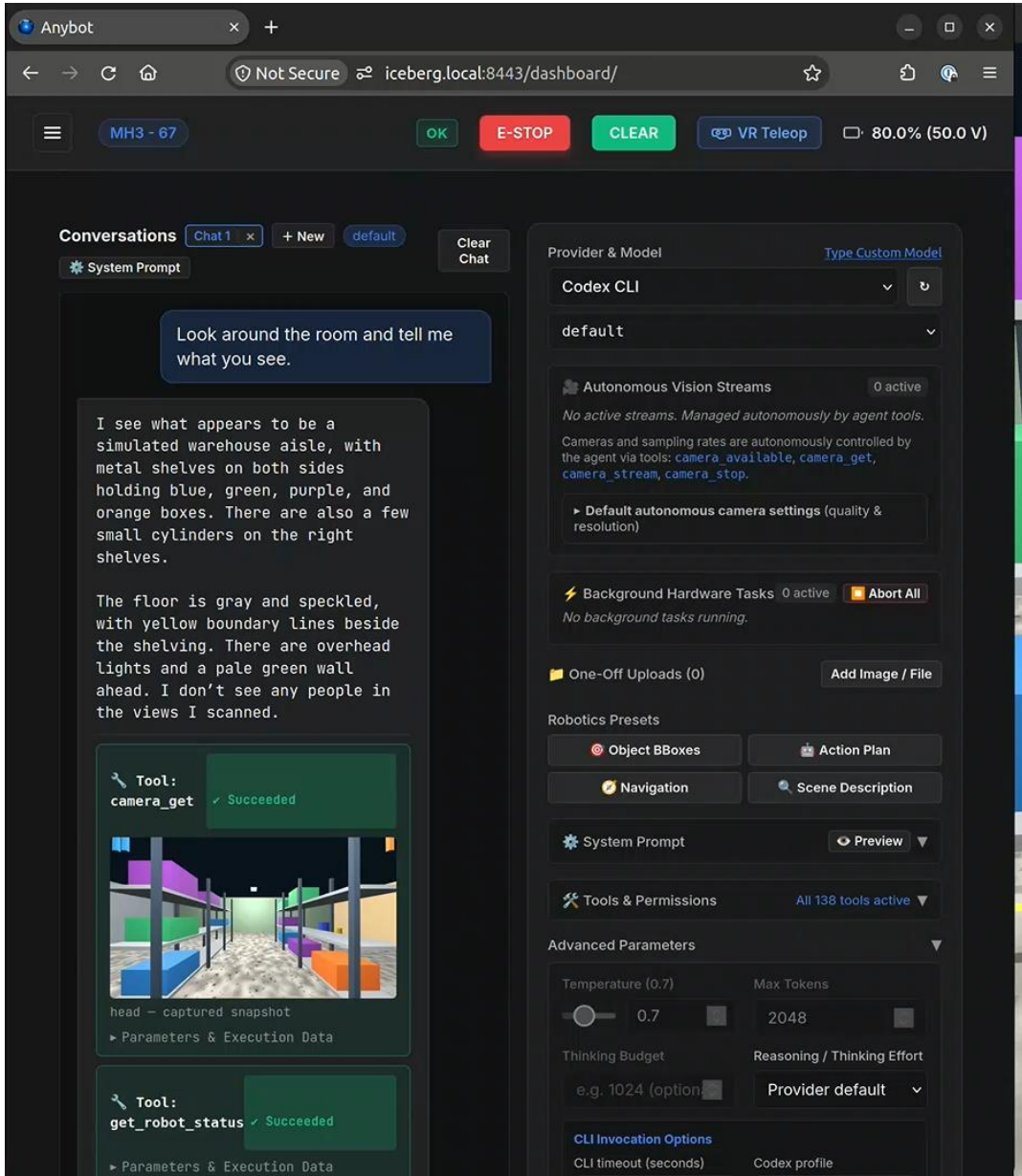


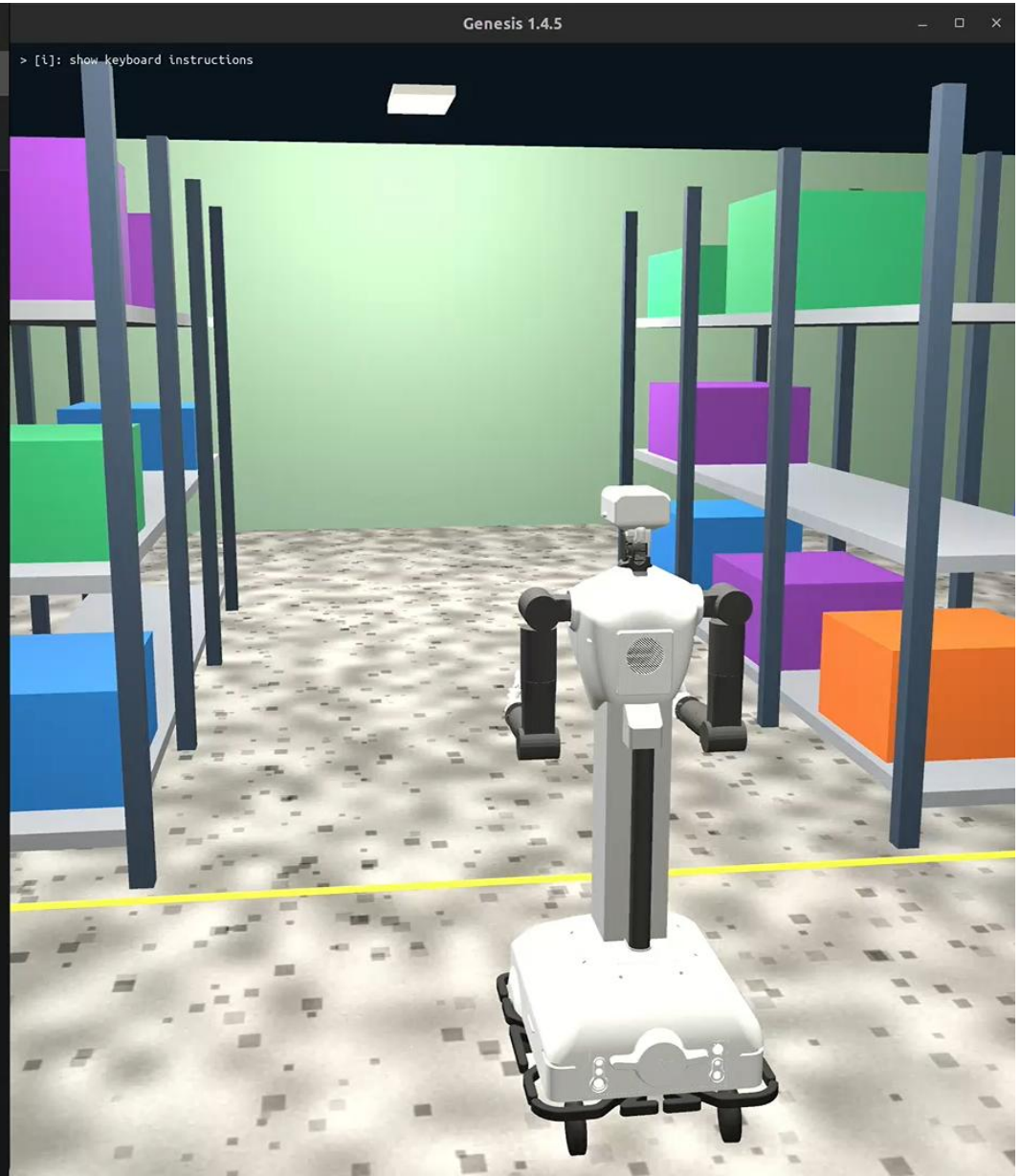
How we should work with Humanoids





How we should work with Humanoids





Thank you for listening

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