# MoveIt Pro

## Accelerating Unstructured Robotics

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PICKNIK

# MoveIt

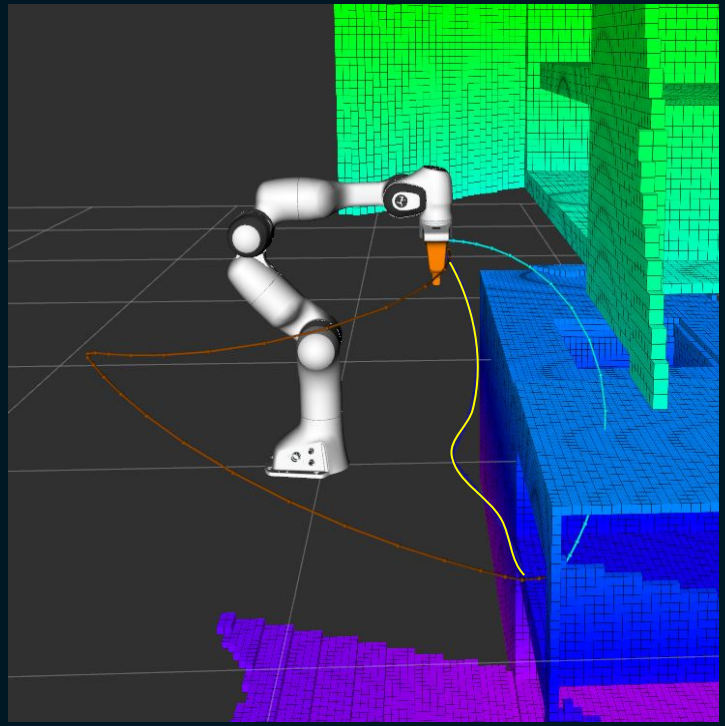
## What's new in open-source?

- Release for ROS 2 Iron
- New parallel planning pipeline
- Reimplementation of STOMP
- Python bindings for MoveIt C++ API
- Major revisions to MoveIt Servo
- Integration with Nvidia Isaac
- Numerous bugfixes!

# MoveIt

## Parallel Planning

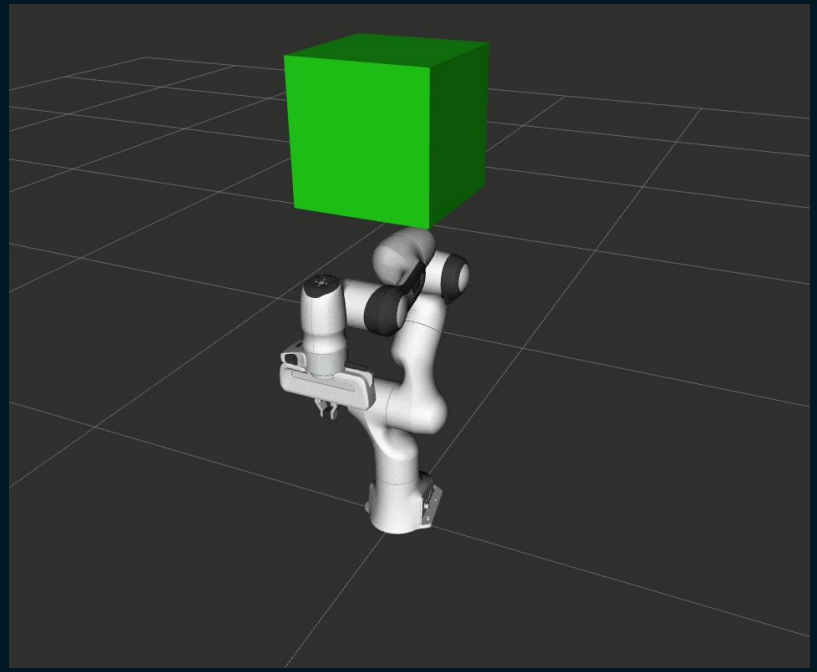
- Create solutions using several different planners, then pick the best one.
  - Can pair fast-but-naive joint interpolation with costly-but-thorough OMPL planners.
- Set criteria for “best” solution.
- Set termination criteria.



# MoveIt

## STOMP

- Stochastic Trajectory Optimization for Motion Planning
- Given an initial guess, optimize for a smooth collision-free path.
- Can use various cost terms to influence the optimization.



# MoveIt Pro

## Runtime & Developer Platform

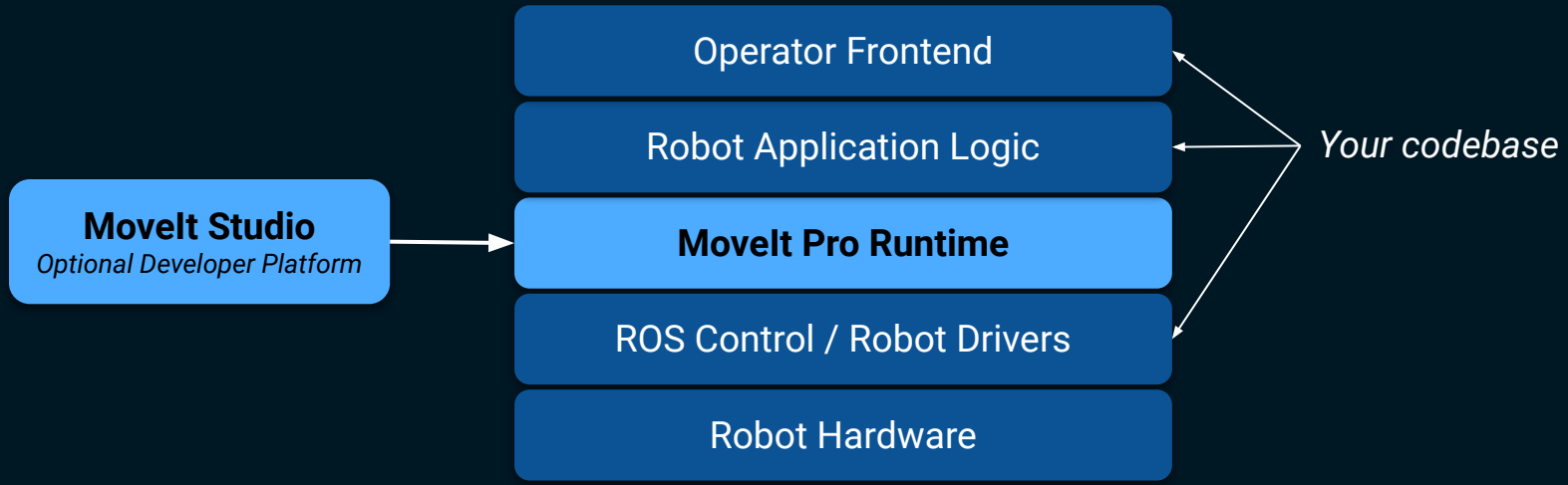
Rapid development of advanced arm control applications for high reliability, commercial-grade implementations.

**Product Walkthrough**

PICKNIK

MoveIt Pro

# Two Primary Components



# Key Features of the MoveIt Pro Runtime

**Drop-in Motion Control Capabilities**

- Motion planning
- Task planning
- Kinematics
- Collision checking
- Visual servoing
- Singularity-free Cartesian planning
- Constraint-based planning
- Basic waypoint following

**Drop-in Perception Capabilities**

- ML object recognition
- Point cloud processing
- 3D mesh registration
- Classical computer vision
- AR tag tracking
- Hand-to-eye calibration

**Drop-in Force Sensitive Motions**

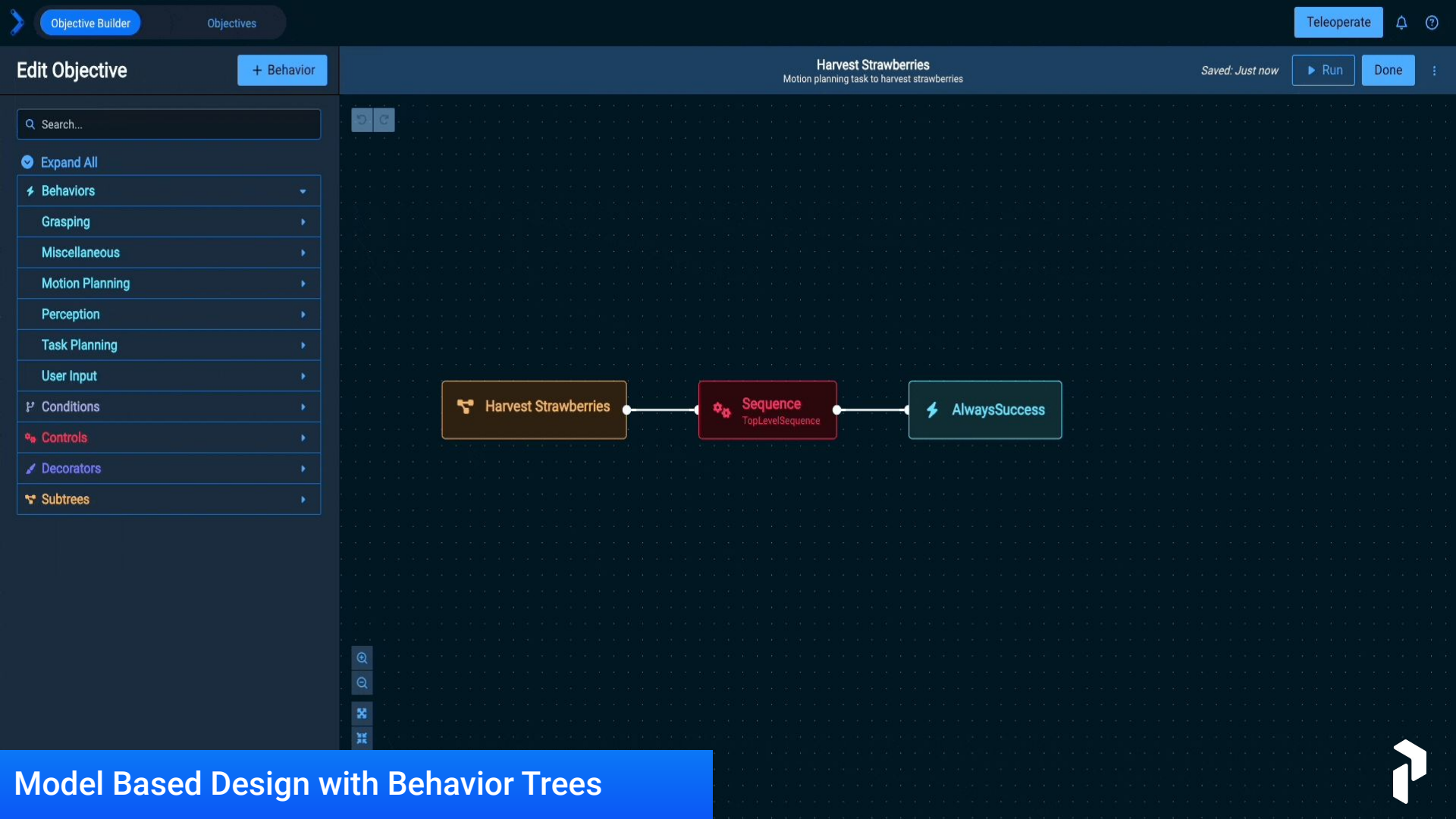
- Force-guarded motions
- Admittance-controlled motions

**Drop-in Grasping Capabilities**

- Two-finger grasping
- Vacuum grasping

**Infrastructure**

- State management with behavior trees
- Error recovery and fault tolerance
- Enhanced data logging & reporting
- Docker containers for reproducible developer and robot deployment
- Regular security patches, maintenance, and reliability testing




# Model Based Design with Behavior Trees

# A Growing Library of Runtime Behaviors

## Motion Planning

- InitializeMotionConstraints
- CallTriggerService
- AddSubframeToObject
- MoveGripperAction
- TransformPose
- TransformPoseFrame
- TransformPoseFromYaml
- AppendOrientationConstraint
- MoveToWaypoint
- FollowJointTrajectory
- ForceExceedsThreshold
- LoadJointTrajectoryFromYaml
- ReadTextFileAsString
- GetMoveAlongArcSubframes
- AveragePoseStamped
- ActivateControllers
- AddPointCloudToVector
- AddPoseStampedToVector
- AlwaysSuccess
- AlwaysFailure
- CalculatePoseOffset
- CreateStampedPose
- GenerateObjectsInBox
- ExecuteFollowJointTrajectory
- GetLatestTransform
- PlanCartesianPath
- UpdateAdmittanceController
- ValidateTrajectory
- PoseStreamFilter
- ReadTextFileAsString
- SaveJointTrajectoryToYaml
- SavePoseStampedToYaml
- SavePoseToYaml
- Script
- SetBlackboard

## Task Planning

- InitializeMTCTask
- PlanMTCTask
- PushToSolutionQueue
- ExecuteMTCTask
- SetupMTCCurrentState
- SetupMTCApproachObject
- SetupMTCAttachObject
- SetupMTCCartesianMoveToJointState
- SetupMTCCartesianSequence
- SetupMTCDetachObject
- SetupMTCFixedJointState
- SetupMTCFromSolution
- SetupMTCMoveToJointState
- SetupMTCMoveToNamedState
- SetupMTCMoveToPose
- SetupMTCInterpolateToJointState
- SetupMTCUpdateGroupCollisionRule
- SetupMTCUpdateObjectCollisionRule
- SetupMTCMoveAlongFrameAxis
- SetupMTCPickObject
- SplitMTCSolution

## Vision & Perception

- CheckCuboidSimilarity
- ClearSnapshot
- CropPointsInBox
- DetectApriltags
- DetectObjects
- FindMaskedObjects
- FindSingularCuboids
- GetButtonFromDetections
- GetCameraInfo
- GetDetectionPose
- GetDoorHandle
- GetImage
- GetMasks2dAction
- GetMasks3dFromMasks2D
- GetPointCloud
- GetPointCloudFromMasks
- GetPointCloudFromMasks2D
- GetPointCloudFromMasks3D
- GetSynchronizedCameraTopics
- LoadImageFromFile
- SaveImageToFile
- TransformPointCloud
- TransformPointCloudFrame
- CreatePoseAction
- GetClosestObjectToPose
- IsConstraintSatisfied

## Grasping

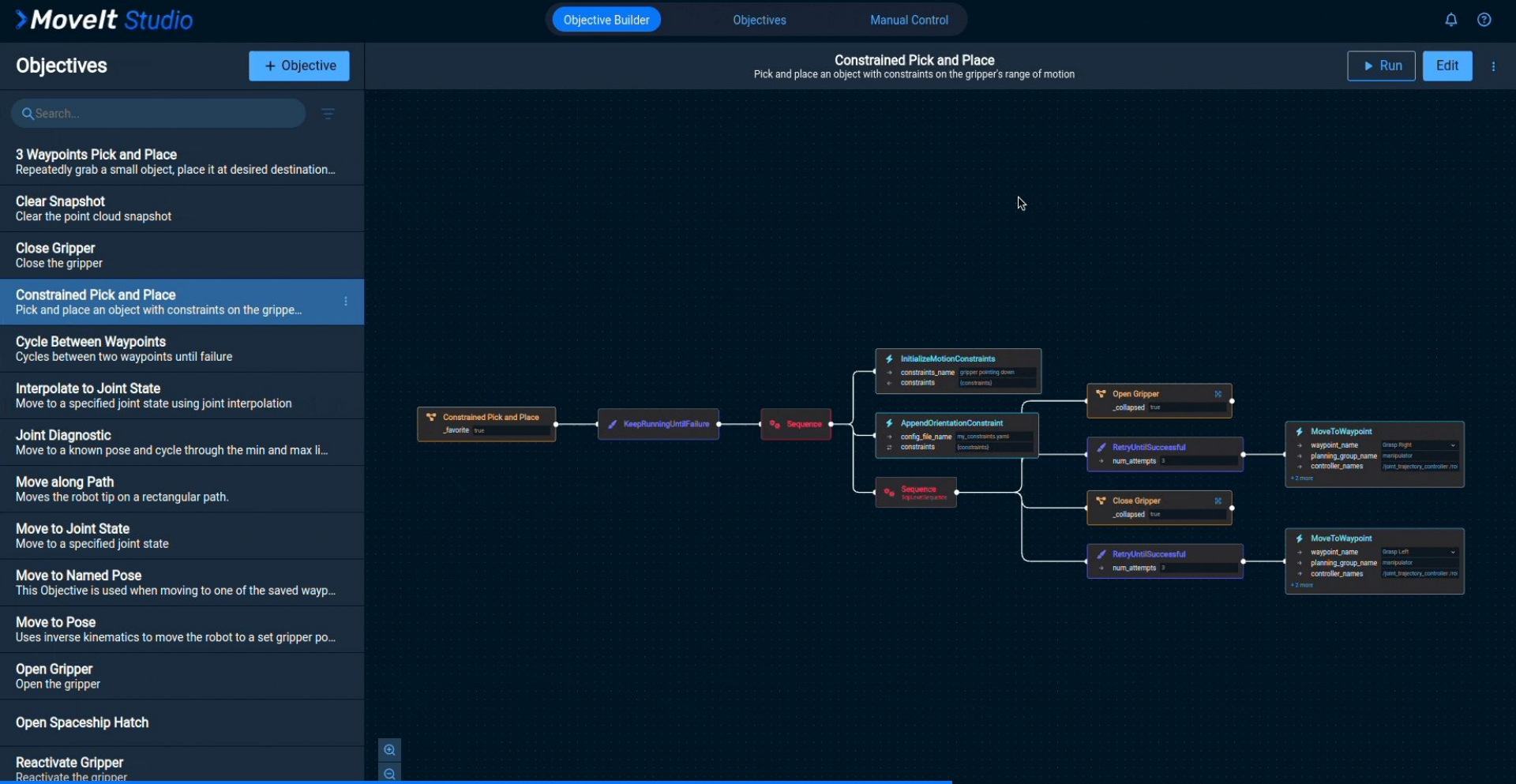
- CreateGraspableObject
- ExtractGraspableObjectPose
- GetGraspAndTwistSubframes
- GetGraspAndTwistSubframes
- SetupMTCApproachGrasp
- SetupMTCGenerateCuboidGrasps
- SetupMTCGenerateVacuumGrasps
- SetupMTCRetractFromGrasp
- SetupGraspThenMoveAlongArcPull
- SetupGraspTwistMoveAlongArcPush
- GetGraspableObjectsFromMasks3D

## User Input

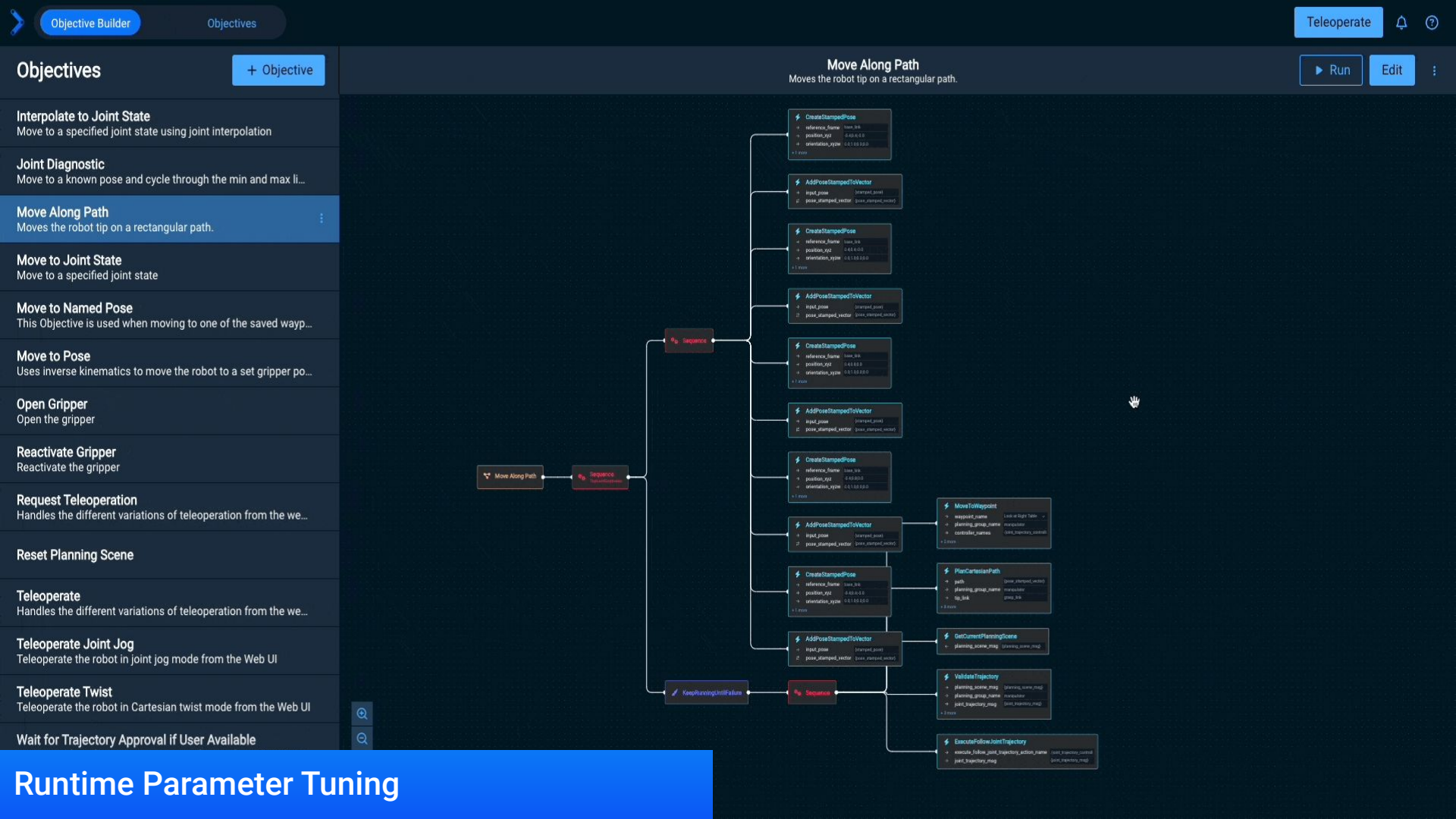
- EditWaypoint
- GetIntFromUser
- GetMoveAlongSubframes
- GetPoseFromUser
- GetStringFromuser
- IsUserAvailable
- LoadPoseStampedFromYaml
- LoadPoseStampedVectorFromYaml
- LogMessage
- DoTeleoperateAction
- IsUserAvailable
- RetrieveJointStateParameter
- RetrievePoseParameter
- RetrieveWaypoint
- SaveCurrentState
- TeleoperateJointJog
- TeleoperateTwist
- WaitForDuration
- WaitForUserTrajectoryApproval

**Over 150 pre-built skills and behaviors!**

**(and a developer API for adding your own!)**




# Dynamic Subtree Support within Behavior Trees

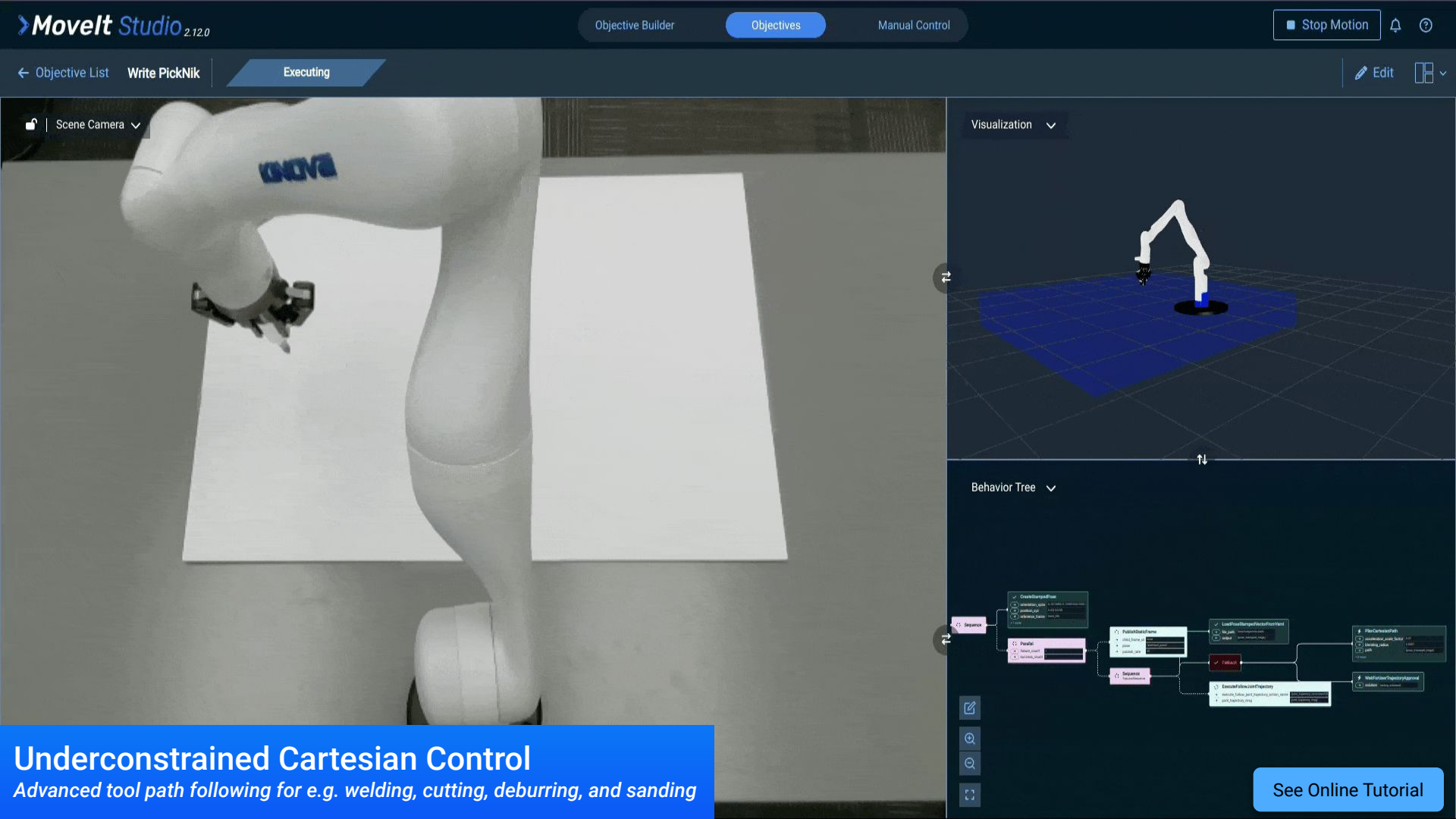


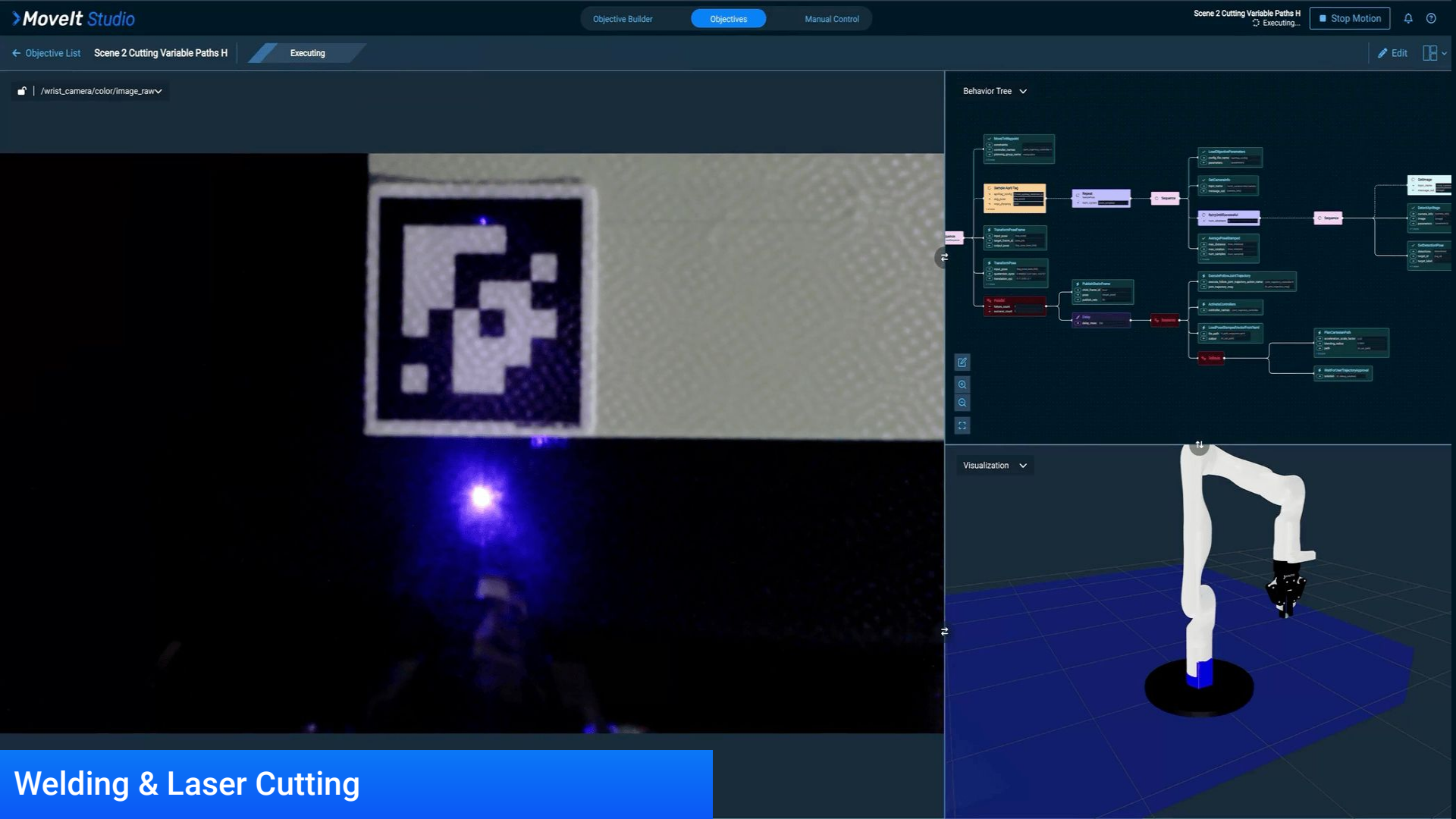

# Runtime Parameter Tuning

# Reference Applications

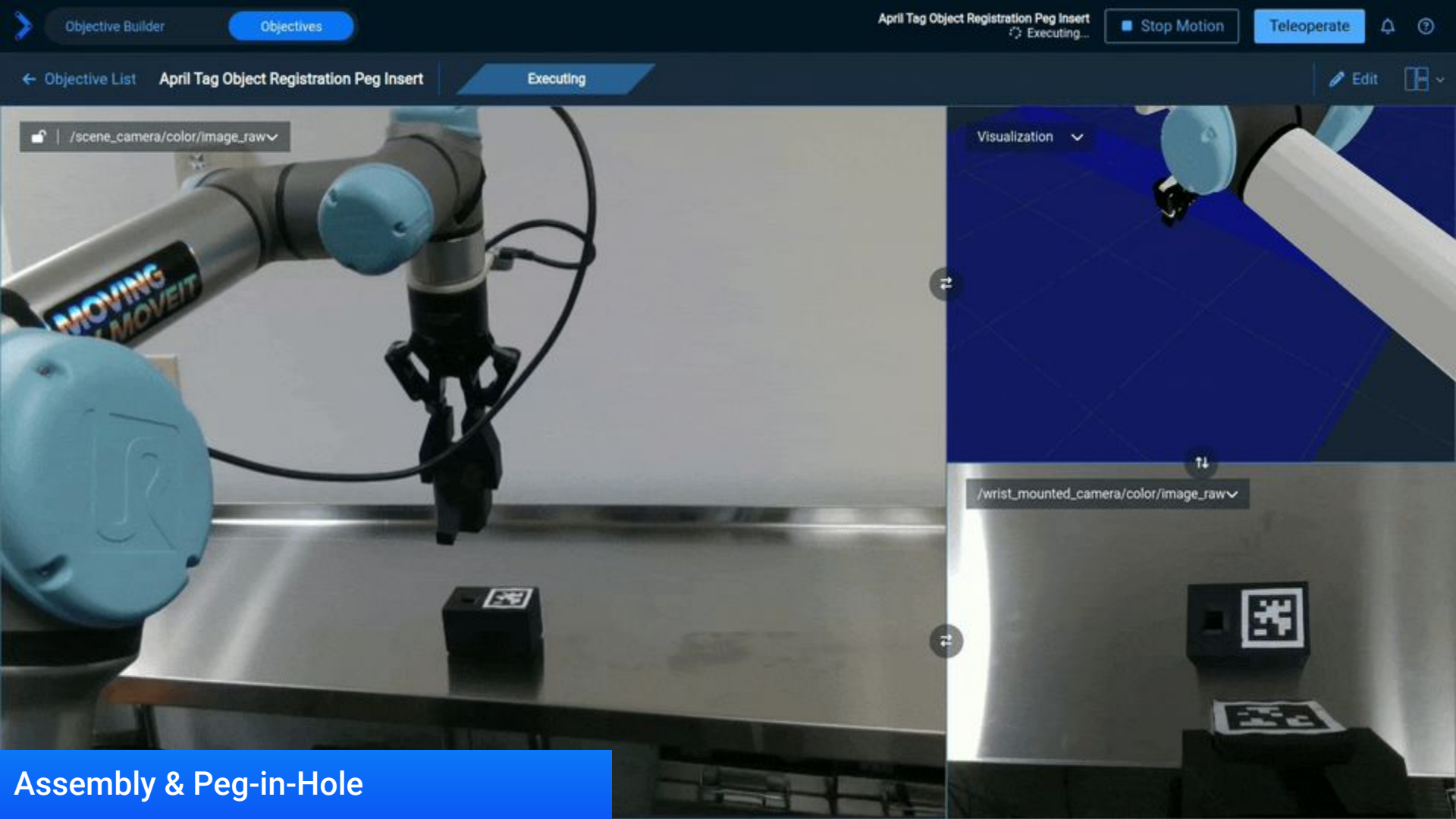
**Example templates that:**

- Provide adaptable code and architecture patterns
- Speed up building custom robotics applications
- Facilitate training and onboarding

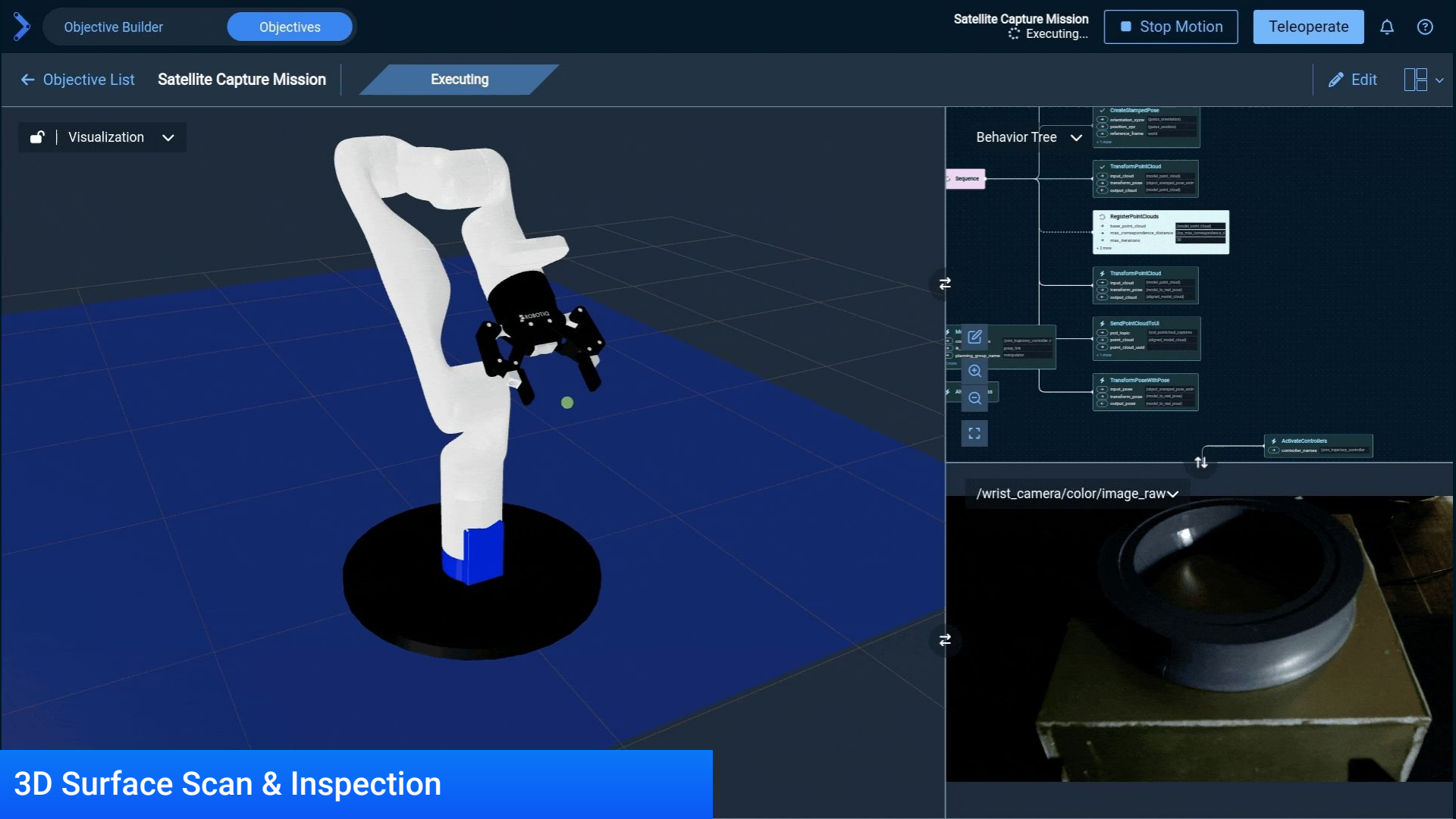

MoveIt Studio 2.12.0
Objective Builder
Objectives
Manual Control
Stop Motion
Objective List
Write PickNik
Executing
Edit
Scene Camera
Visualization
Behavior Tree
Underconstrained Cartesian Control
Advanced tool path following for e.g. welding, cutting, deburring, and sanding
See Online Tutorial

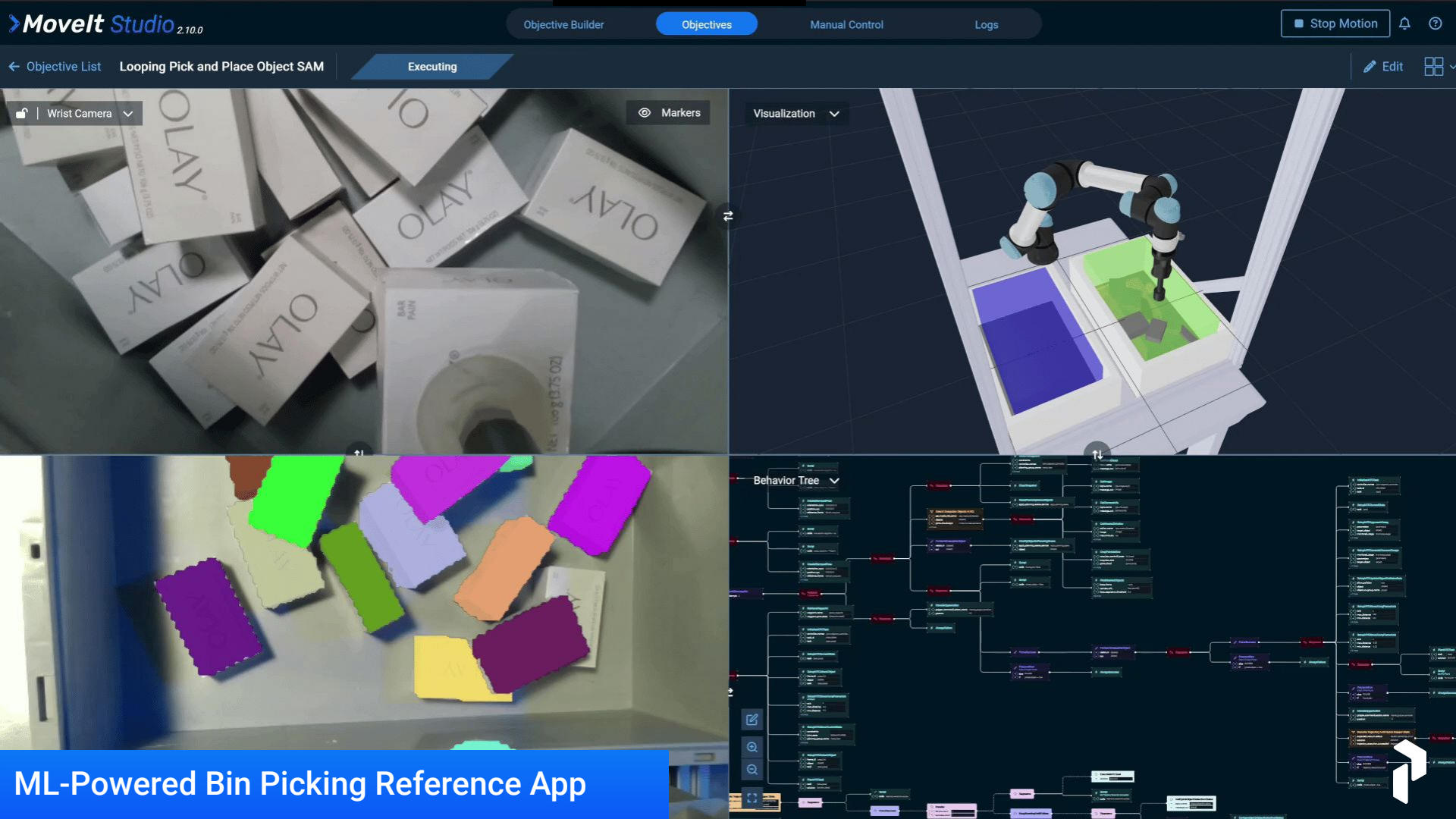


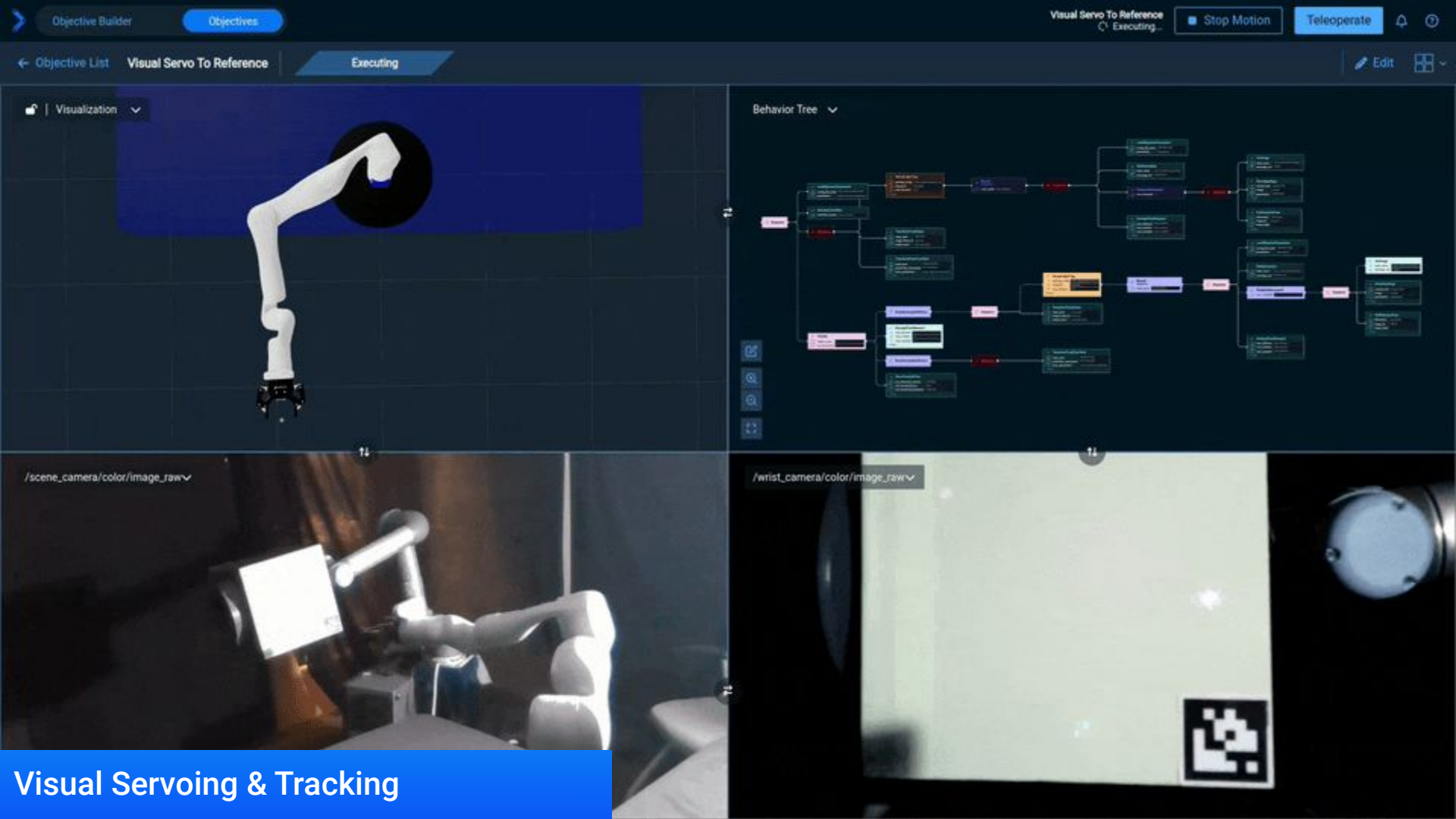

# Welding & Laser Cutting



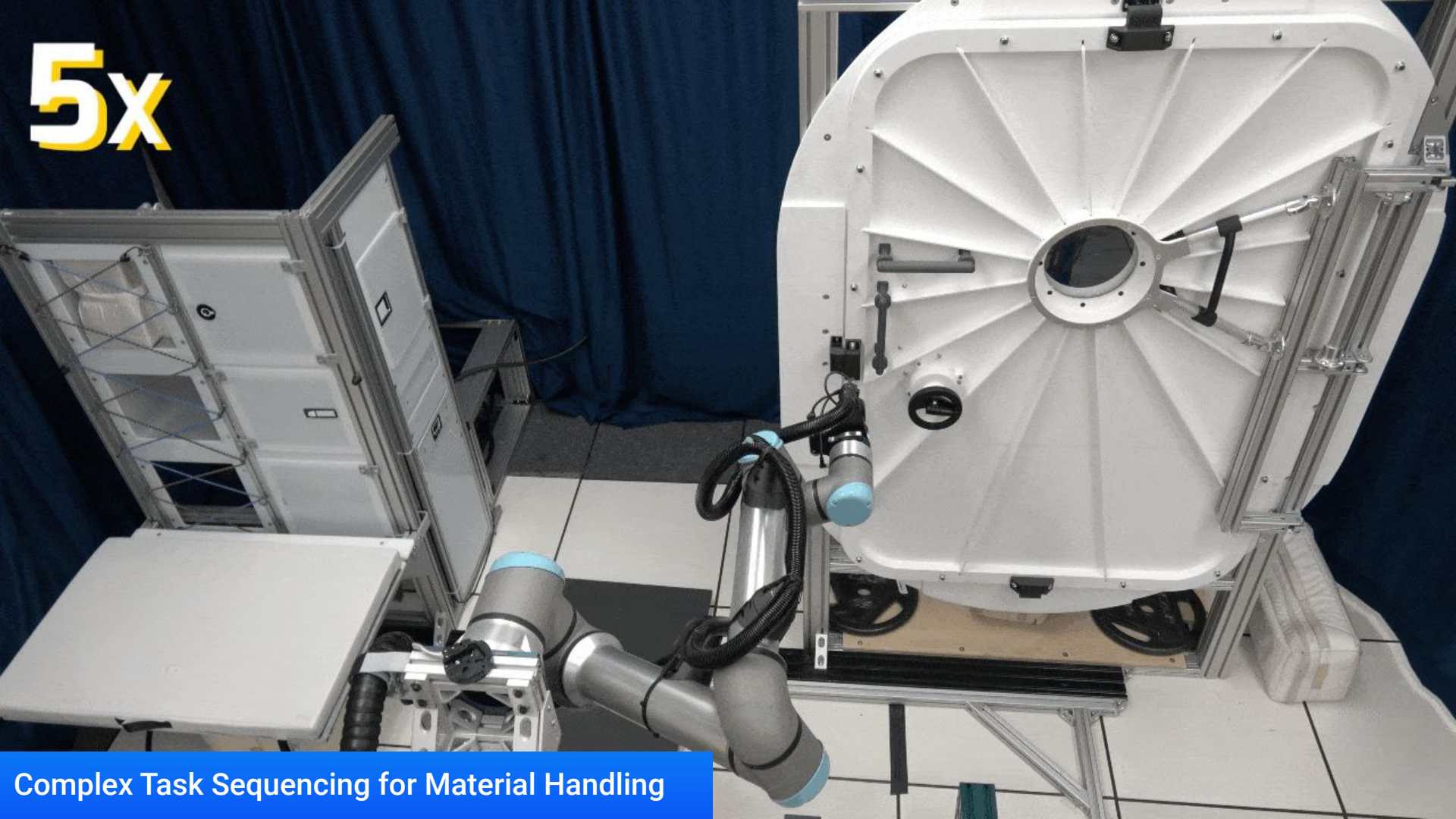

# Assembly & Peg-in-Hole


Objective Builder
Objectives
Satellite Capture Mission
Executing...
Stop Motion
Teleoperate
Objective List
Satellite Capture Mission
Executing
Edit
Visualization
Behavior Tree
/wrist_camera/color/image_raw
3D Surface Scan & Inspection


MoveIt Studio 2.10.0
Objective Builder
Objectives
Manual Control
Logs
Stop Motion
Objective List
Looping Pick and Place Object SAM
Executing
Edit
Wrist Camera
Markers
Visualization
Behavior Tree
ML-Powered Bin Picking Reference App




# Visual Servoing & Tracking




Complex Task Sequencing for Material Handling

MoveIt Studio 2.11.0

Objective Builder | Objectives | Manual Control | Logs

## Edit Objective

+ Behavior

Search...

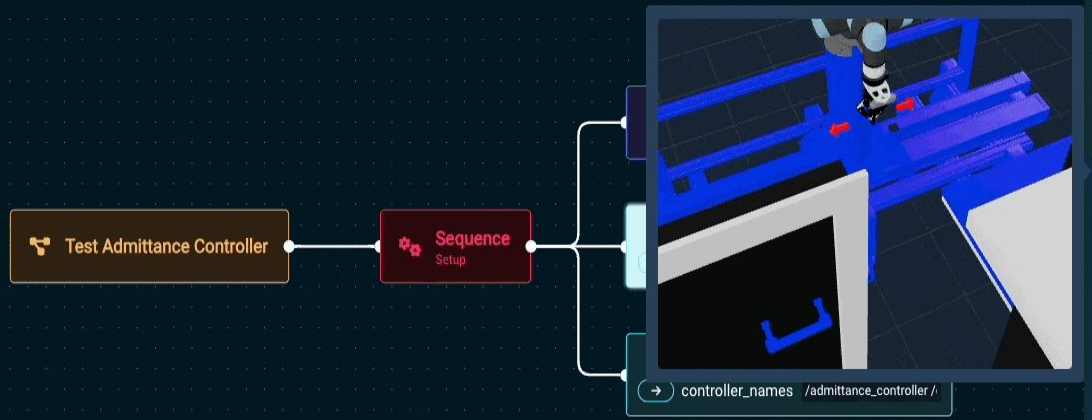
- Expand All
- Behaviors
  - Grasping
  - Miscellaneous
  - Motion Planning
  - Perception
  - Task Planning
  - User Input
- Conditions
- Controls
- Decorators
- Subtrees

Run

**Test Admittance Controller**

Run this objective and push on the robot end effector to check if admittance works!

*Saved: Just now* Done




config_file_name

test_admittance_controller_config.yaml

Configuration file name.

**Admittance Control**

Control Frame: grasp_link

Base Frame:

Controller Name: admittance_controller

| Axis | Mass | Damping | Stiffness |
|---|---|---|---|
| X | Mass (kg): 0.001 (0.001 – 100) | Damping ratio: 0 (0 – 100) | Stiffness (N/m): 530.87 (0 – 1000) |
| Y | 0.001 | 5 | 500 |
| Z | 10 | 5 | 500 |
| RX | 0.001 | 5 | 100 |
| RY | 0.001 | 0 | 0 |
| RZ | | | |

# Easy Admittance & Force Control Tuning in Real-time

Apply specified amount of forces in certain axes

See Online Tutorial

MoveIt Studio 2.11.0

Objective Builder | Objectives | Manual Control | Logs

Constraints

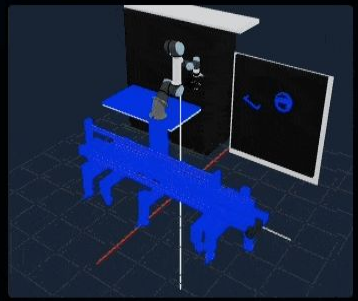
Done

world

Frames

Constraint Frame

world



Link Frame

ur_to_robotiq_link

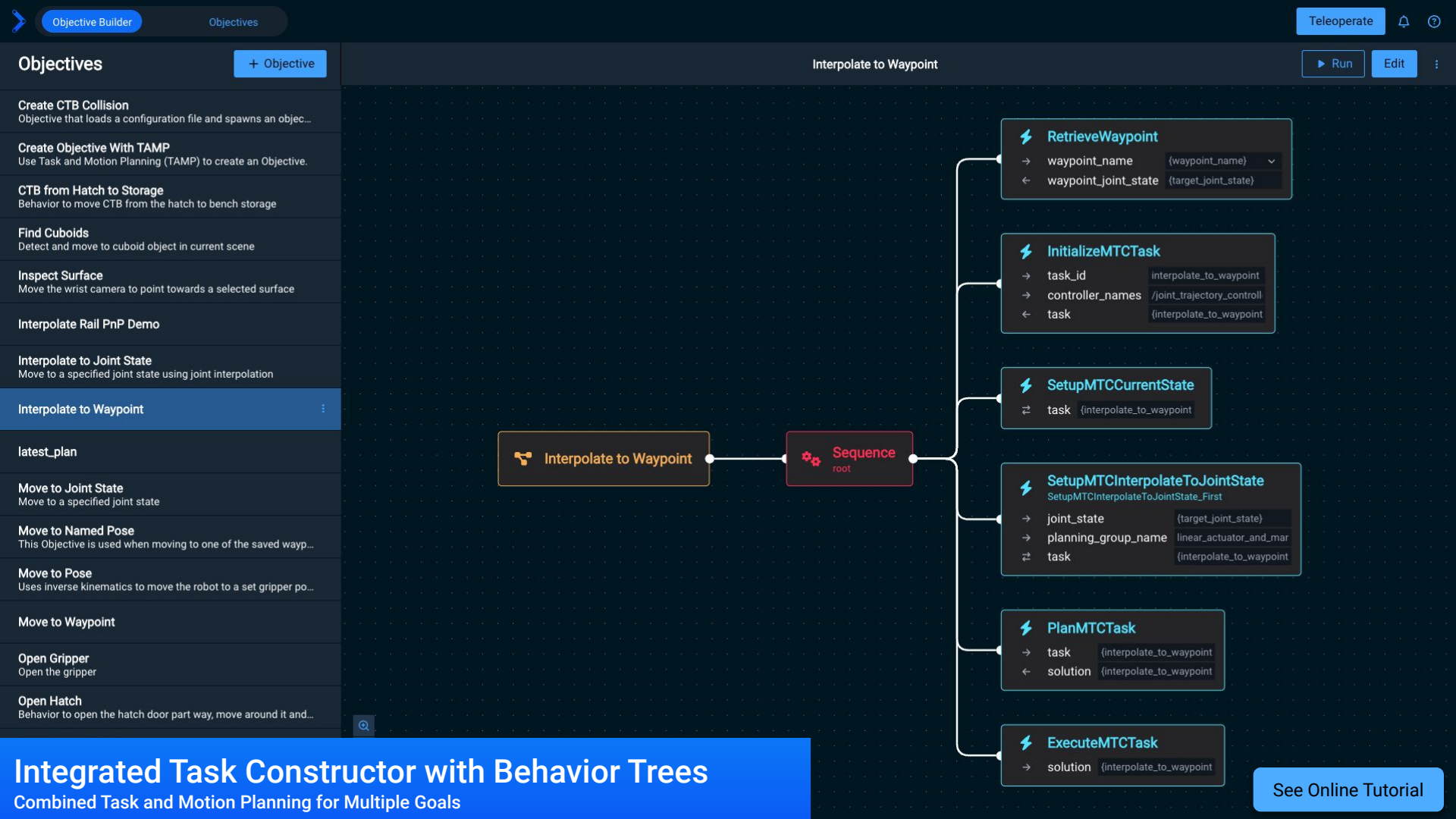
Orientation & Tolerances

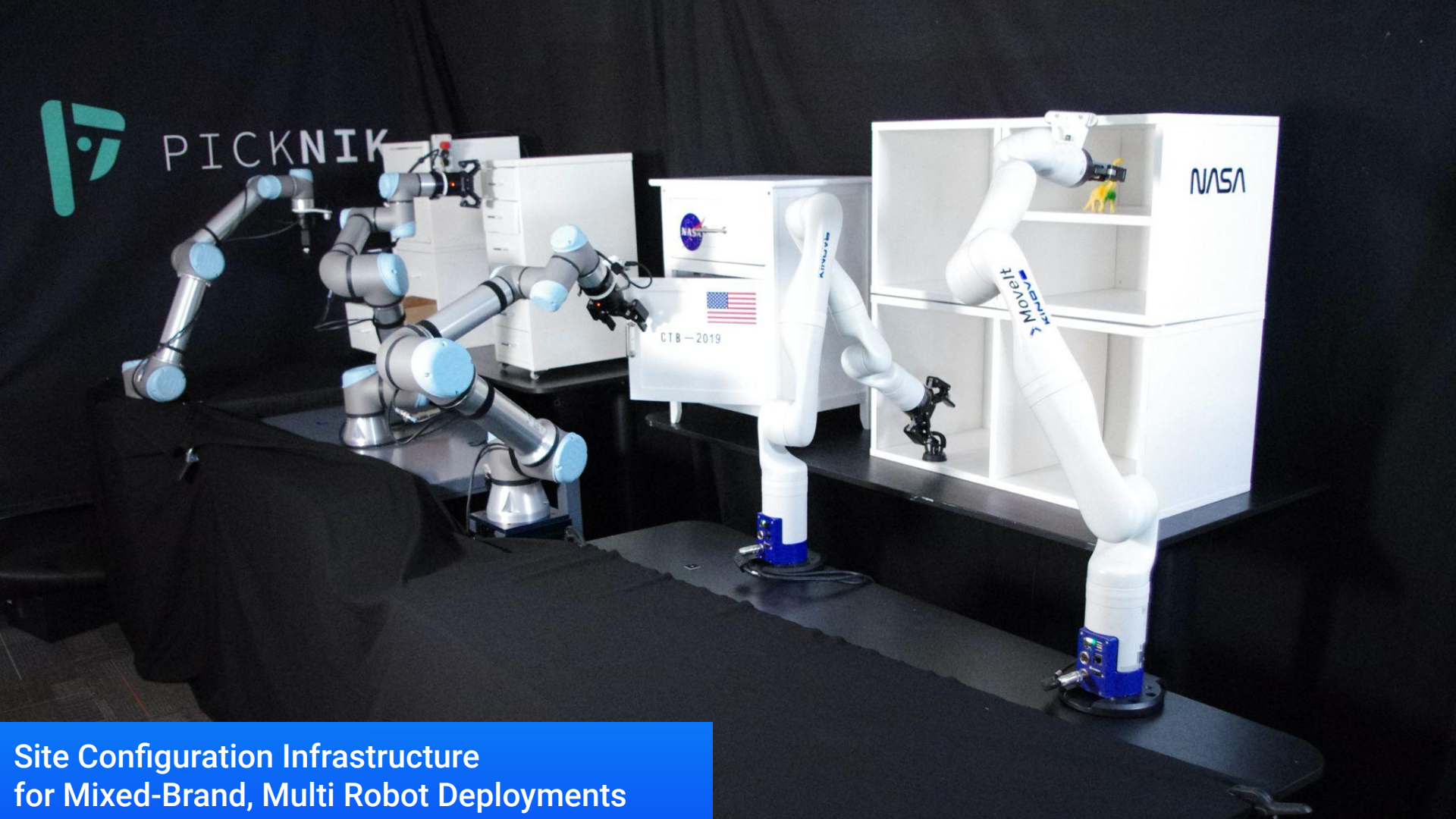
| Axis | Orientation | Tolerance(+/-) |
|---|---|---|
| X | 0.05 rad | 0 rad |
| Y | 0 rad | 0 rad |
| Z | -1.39 rad | 0 rad |

# Easy Constraint-Based Planning Configuration

Specify the orientation of the end effector during motions

See Online Tutorial


Objective Builder
Objectives
Teleoperate
Objectives
+ Objective
Create CTB Collision
Objective that loads a configuration file and spawns an objec...
Create Objective With TAMP
Use Task and Motion Planning (TAMP) to create an Objective.
CTB from Hatch to Storage
Behavior to move CTB from the hatch to bench storage
Find Cuboids
Detect and move to cuboid object in current scene
Inspect Surface
Move the wrist camera to point towards a selected surface
Interpolate Rail PnP Demo
Interpolate to Joint State
Move to a specified joint state using joint interpolation
Interpolate to Waypoint
latest_plan
Move to Joint State
Move to a specified joint state
Move to Named Pose
This Objective is used when moving to one of the saved waypo...
Move to Pose
Uses inverse kinematics to move the robot to a set gripper po...
Move to Waypoint
Open Gripper
Open the gripper
Open Hatch
Behavior to open the hatch door part way, move around it and...
Interpolate to Waypoint
Run
Edit
Interpolate to Waypoint
Sequence
root
RetrieveWaypoint
waypoint_name
{waypoint_name}
waypoint_joint_state
{target_joint_state}
InitializeMTCTask
task_id
interpolate_to_waypoint
controller_names
/joint_trajectory_controll
task
{interpolate_to_waypoint
SetupMTCCurrentState
task
{interpolate_to_waypoint
SetupMTCInterpolateToJointState
SetupMTCInterpolateToJointState_First
joint_state
{target_joint_state}
planning_group_name
linear_actuator_and_mar
task
{interpolate_to_waypoint
PlanMTCTask
task
{interpolate_to_waypoint
solution
{interpolate_to_waypoint
ExecuteMTCTask
solution
{interpolate_to_waypoint
Integrated Task Constructor with Behavior Trees
Combined Task and Motion Planning for Multiple Goals
See Online Tutorial




# Site Configuration Infrastructure for Mixed-Brand, Multi Robot Deployments

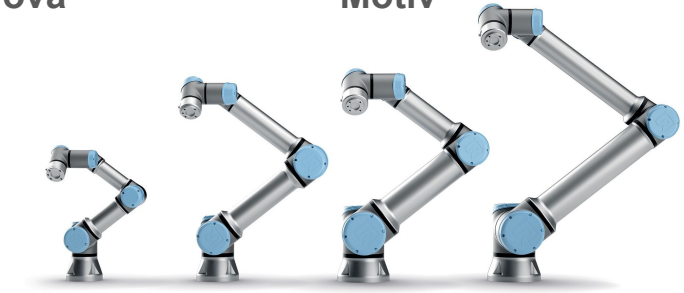
Kinova

Motiv

Ally

Tethers

Tormach



Universal Robotics

**Compatible with any robot with a ROS 2 driver.**

*Pictured: Previously onboarded brands*

HDT Global

# Thank you!

*picknik.ai/connect*

PICKNIK