MATLAB EXPO

借助MATLAB 产品开发智能工业机器人

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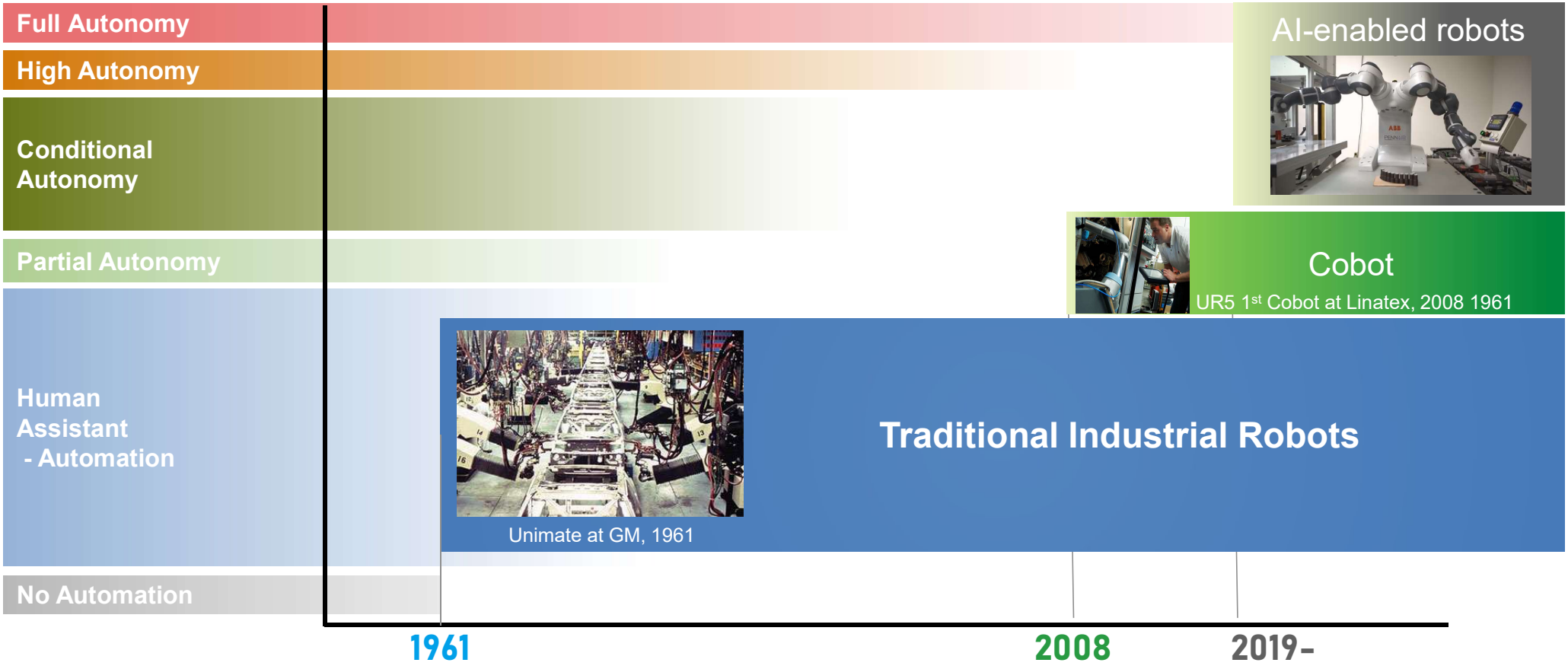
MathWorks®

工业机器人的发展趋势

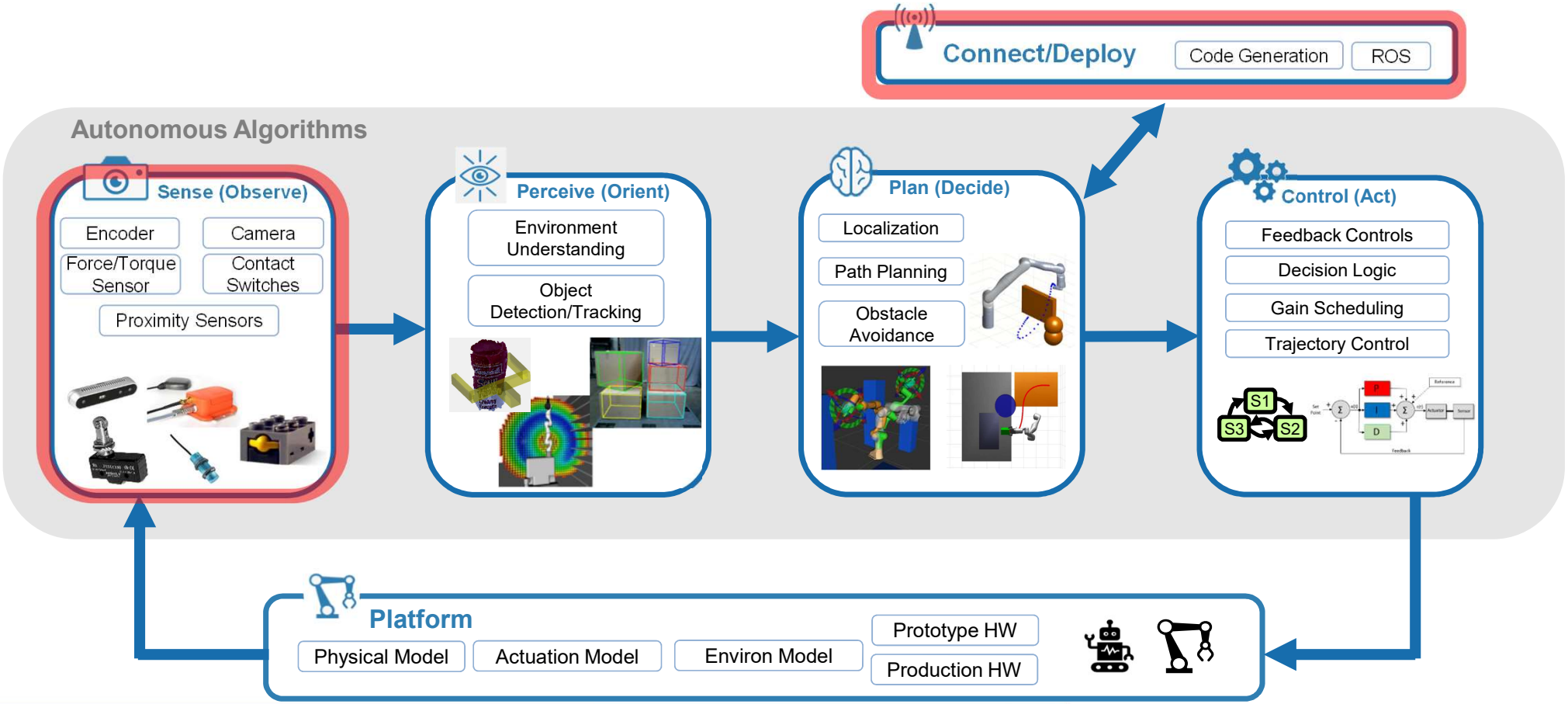
Source: Interact Analysis

工业机器人技术的发展


Full Autonomy
High Autonomy
Conditional Autonomy
Partial Autonomy
Human Assistant - Automation
No Automation
AI-enabled robots
Cobot
UR5 1st Cobot at Linatex, 2008 1961
Traditional Industrial Robots
Unimate at GM, 1961
1961
2008
2019-

自主工业机器人系统开发流程

独立运行，无需人工明确指示



讨论的主题：

自主系统发展的趋势

案例研究：分拣机器人的应用

自主系统的基于模型的设计

用户案例结束语

讨论的主题：

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用户案例
结束语

传统软件开发周期

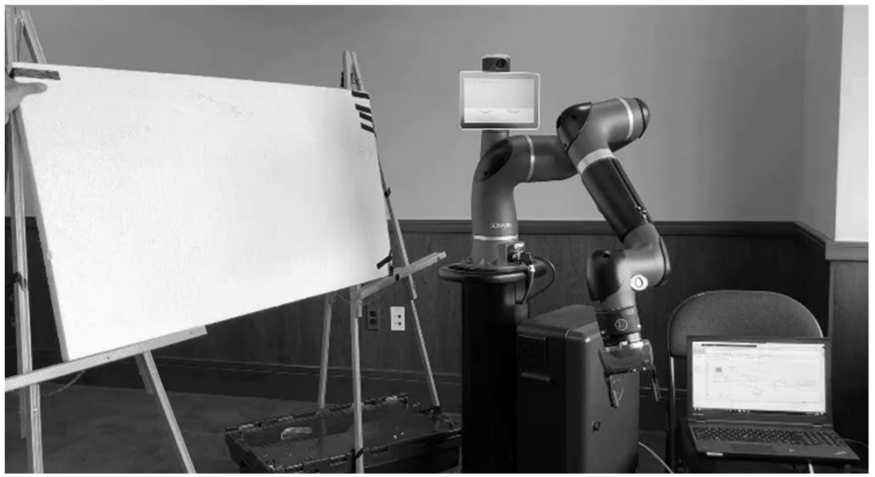
概念设计

手工编码

嵌入式系统

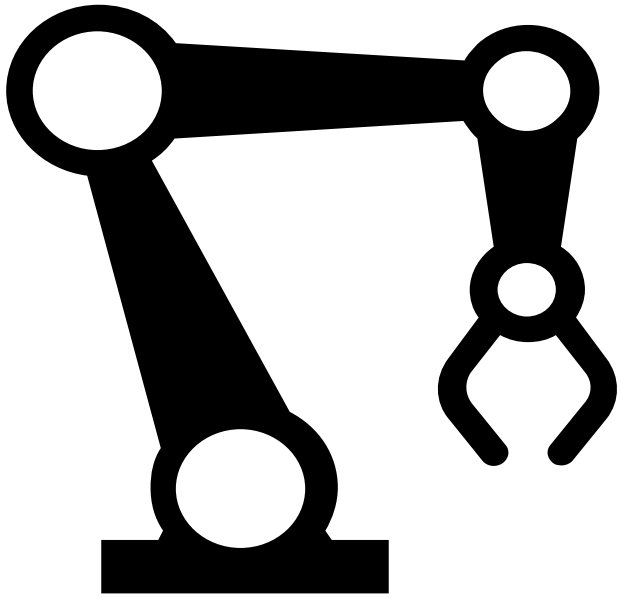
仿真仅花费了6%的设计/开发时间*

* AspenCore - EETimes, “2019 embedded markets study,” EETimes, Tech. Rep., 2019



工业机器人系统开发的挑战

多领域
专业知识



端到端
工作流程

算法的
复杂性

技术深度
和系统稳定性

内容要点

在本讲座中，您将了解

- 工业机器人开发参考工作流程
- 平台、传感、感知、规划和控制的多功能领域
- MATLAB和Simulink开发新的机器人算法的能力
  - » 机器人的运动学和动力学模型
  - » 使用深度学习的感知算法设计
  - » 用于传感器模型和环境仿真的Gazebo联合仿真
  - » 避障路径规划
  - » 使用Stateflow / RL实现逻辑监控和控制
  - » C / C ++代码/ ROS节点生成

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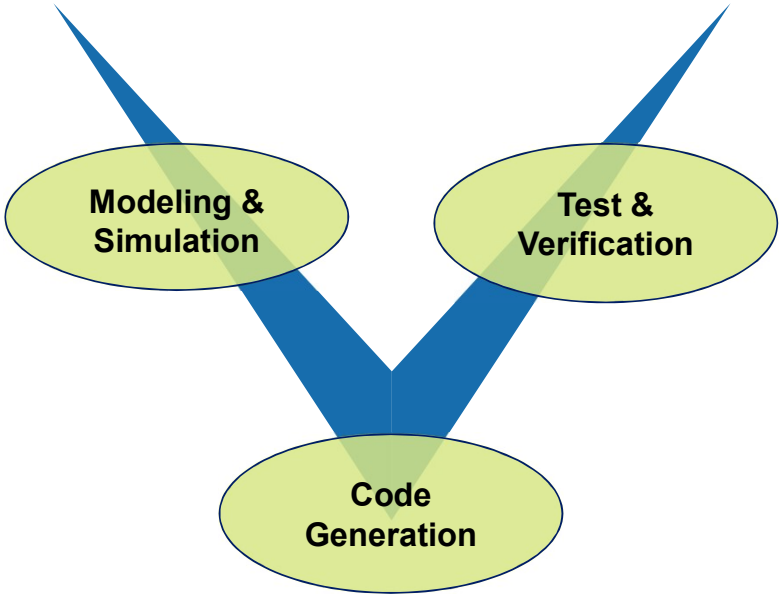
结束语

开发强大的自主系统的关键因素

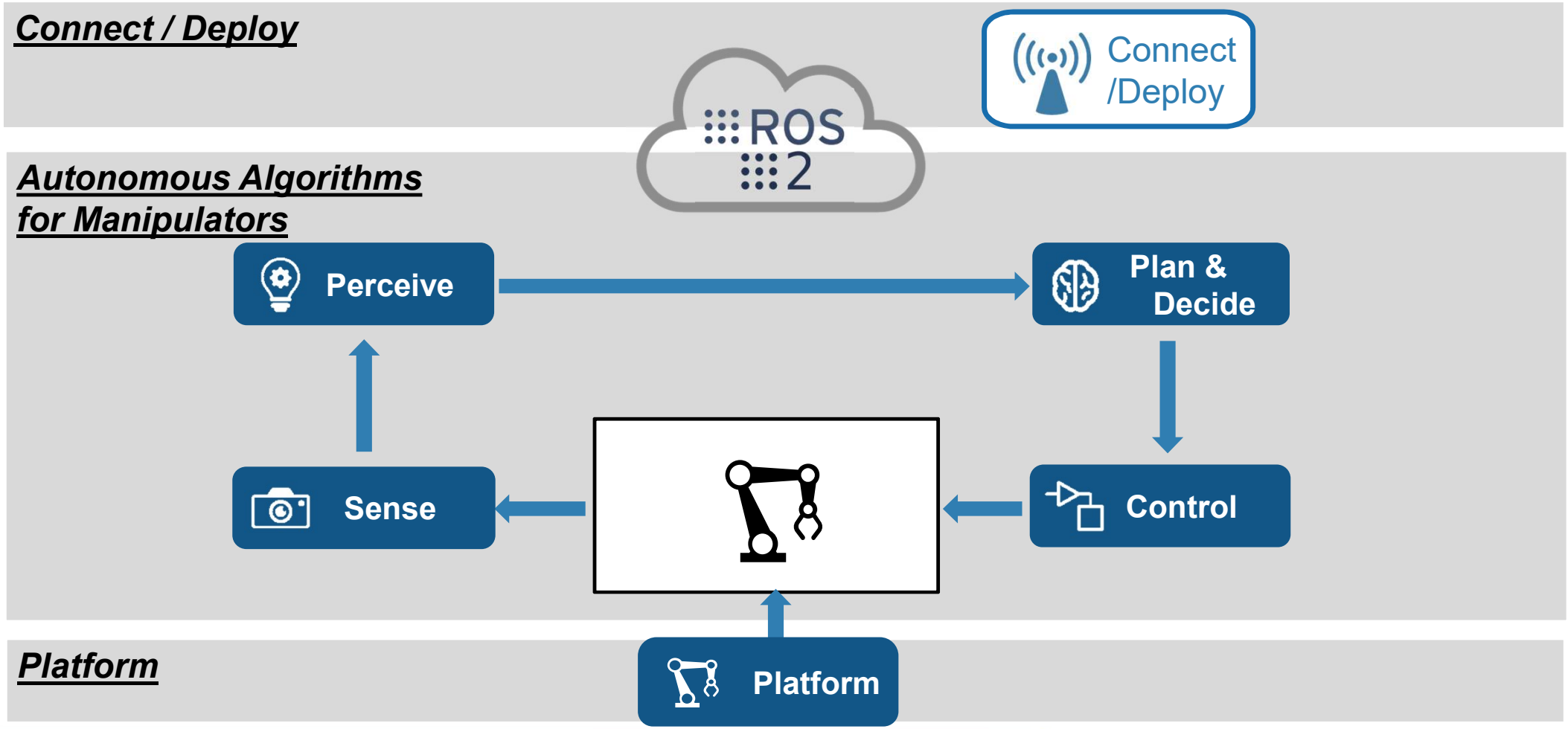


完整的基于模型设计开发流程

必须:包括建模和仿真、代码生成和测试与验证的端到端开发解决方案。

Simulate First and Simulate Often!

完整的基于模型的设计流程



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机械臂的示例

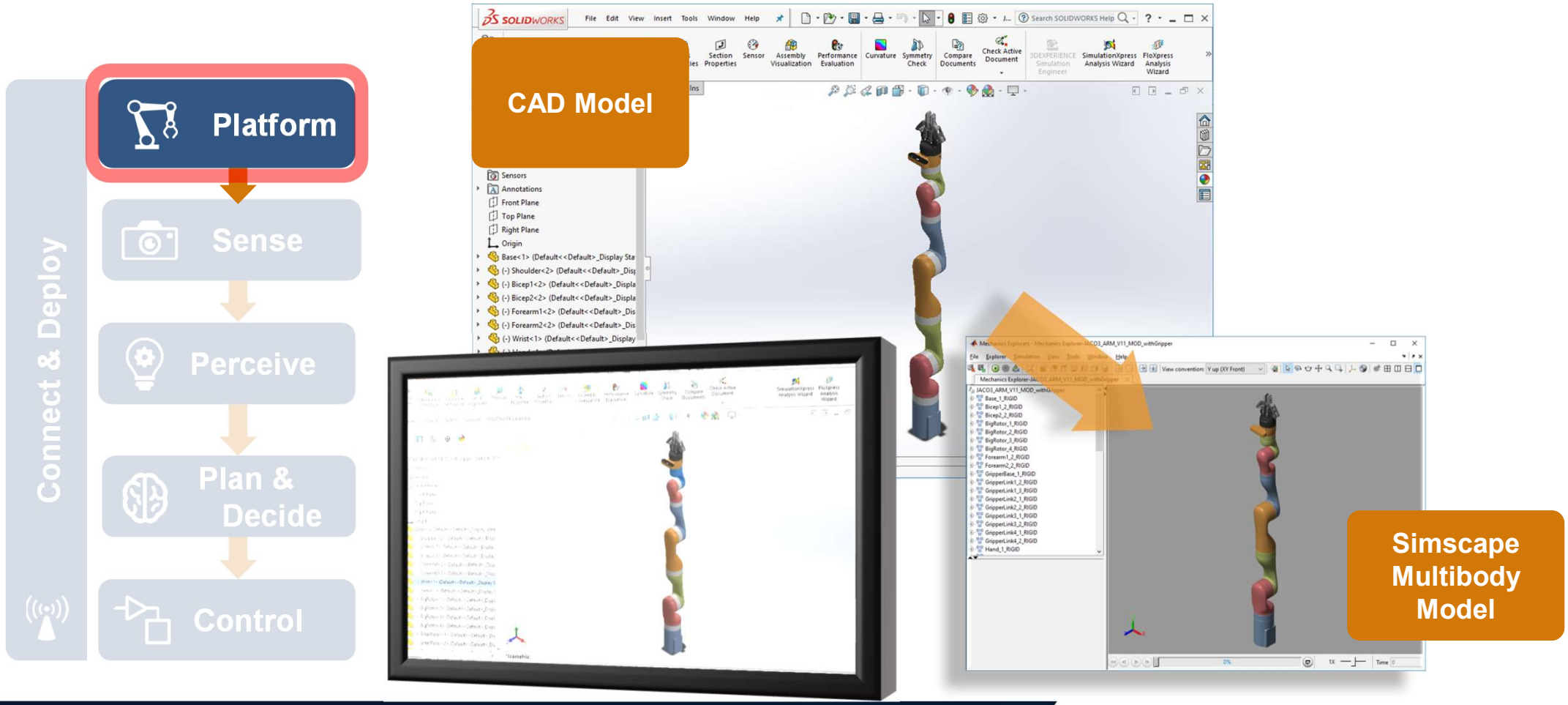
分拣机械手臂

基于模型的设计

深度学习以检测物体

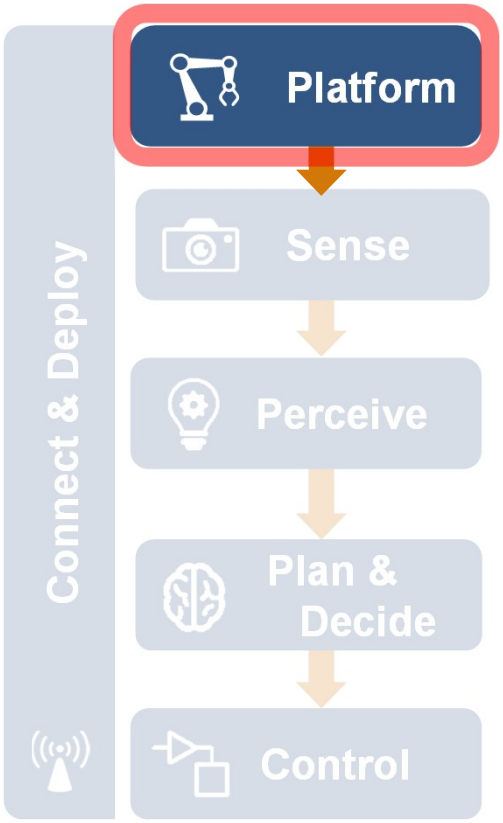
避免碰撞的路径规划

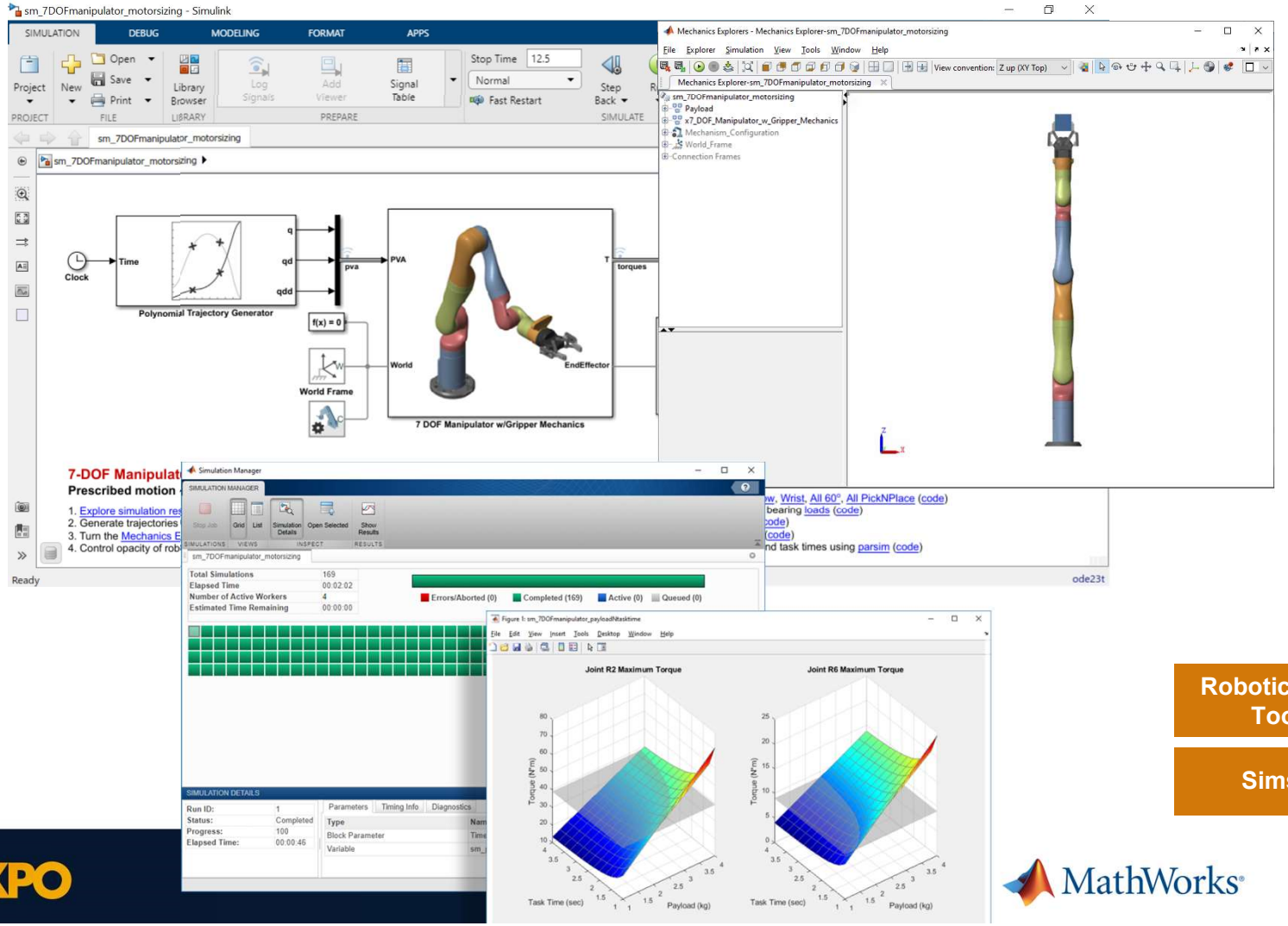
机械系统建模
从CAD工具自动导入



执行机构

评估电机需求–执行机构尺寸





Robotics System Toolbox

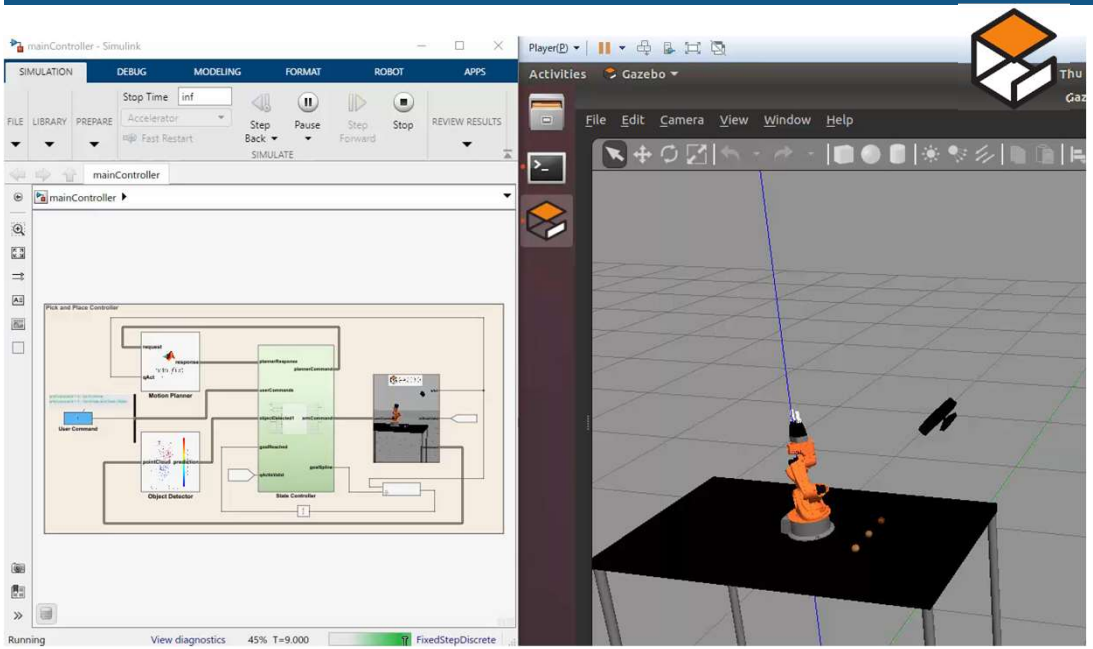
Simscape

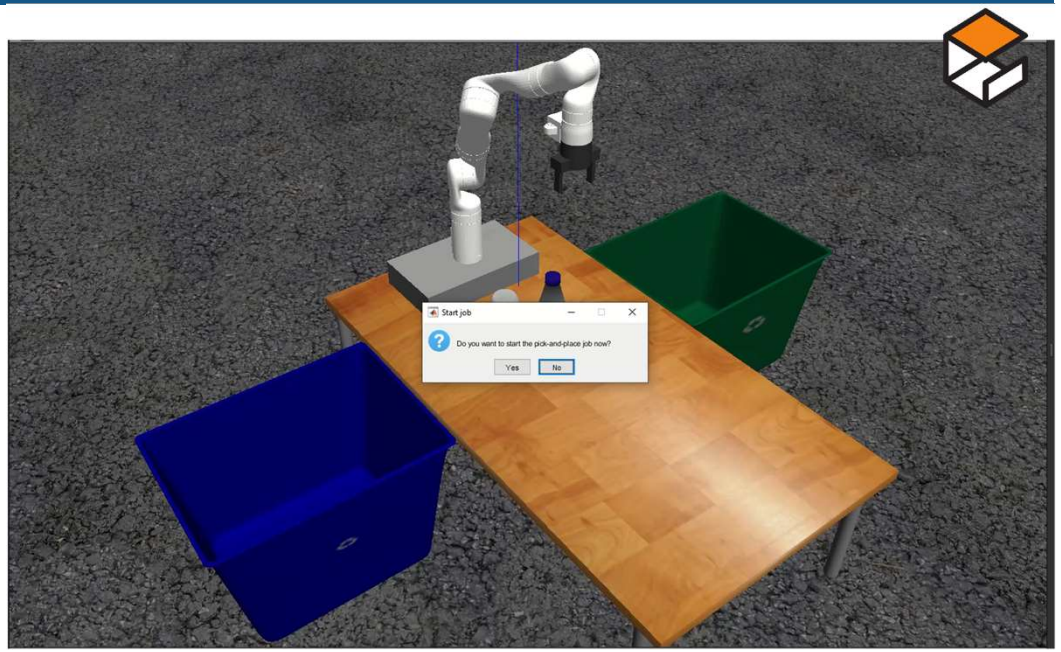
环境建模
连接到外部机器人模拟器

Robotics System Toolbox

ROS Toolbox

Robot arm simulation with Gazebo

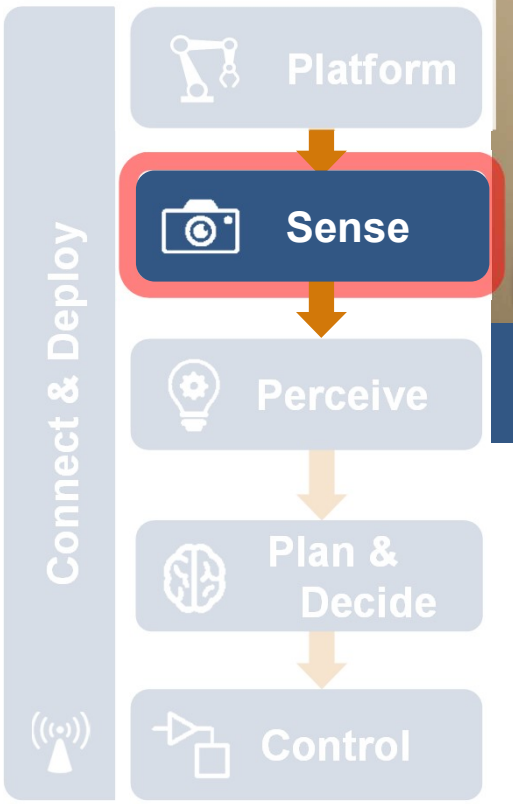


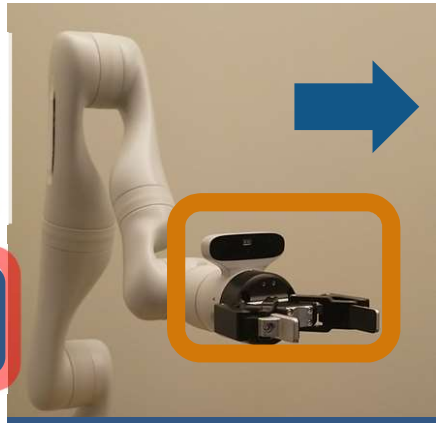


Gazebo: Physics-based simulator with sensors and noise

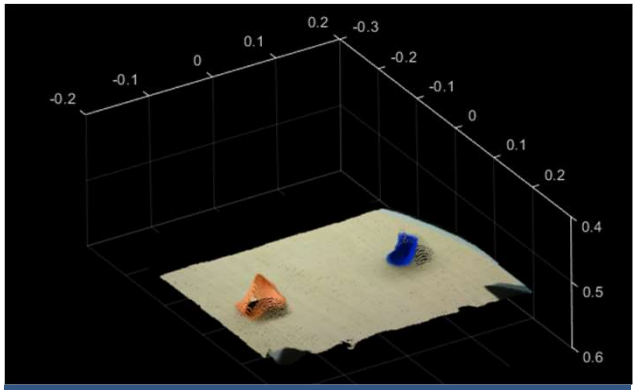
传感器
点云处理用于位姿估计

Computer Vision Toolbox

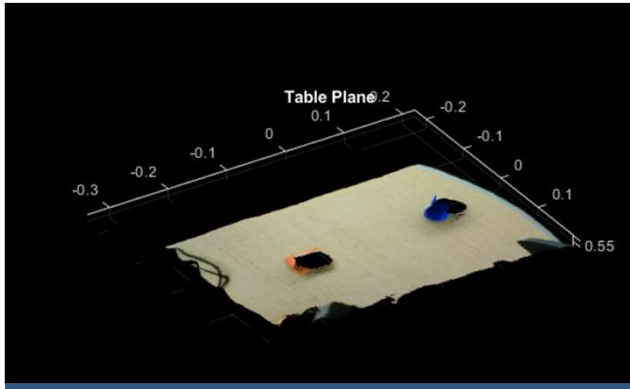




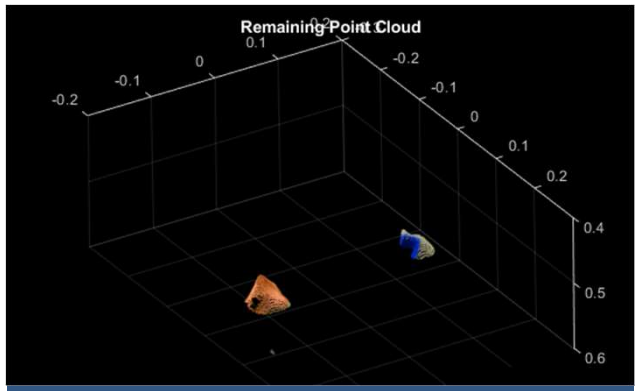
Intel® RealSense™ RGB-D camera



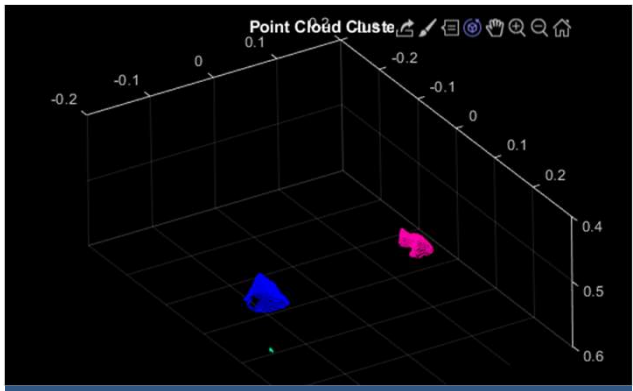
Colorized point cloud



Detect table



Point clouds of objects



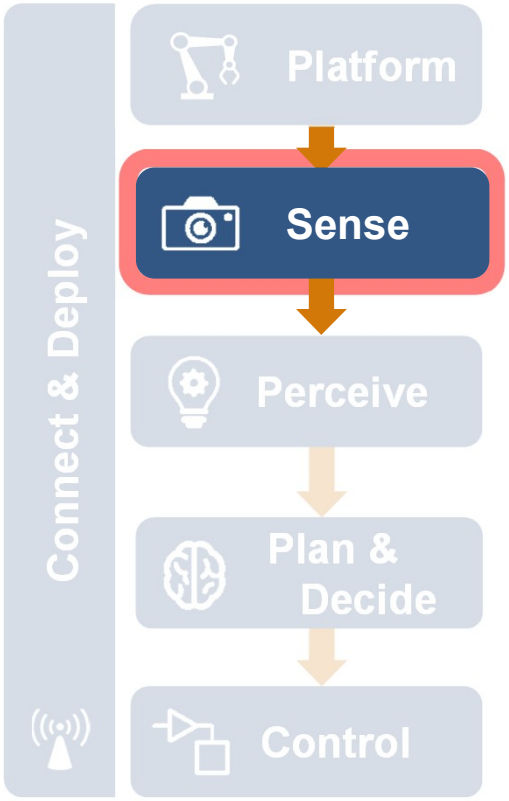
Remove noise and cluster

传感器

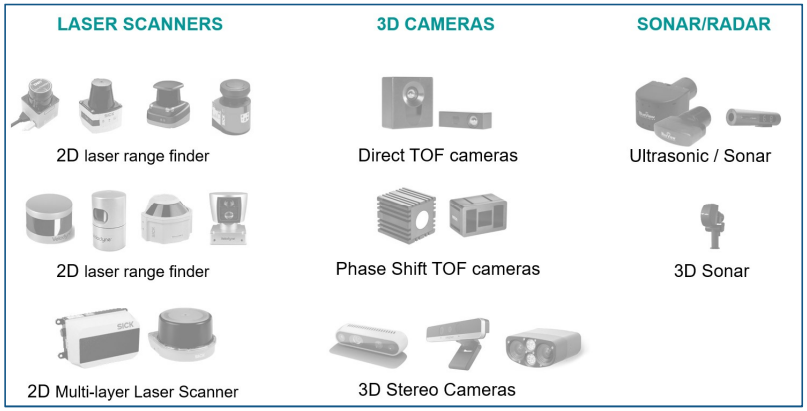
自主系统的通用传感器和传感功能

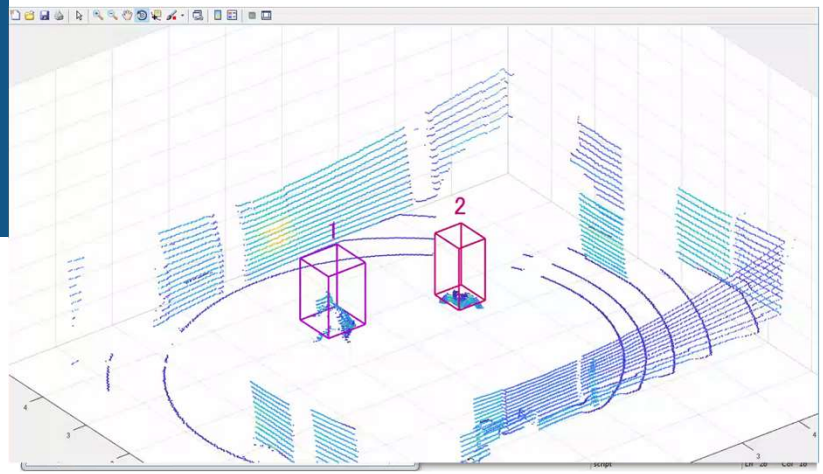
Computer Vision Toolbox

Image Processing Toolbox



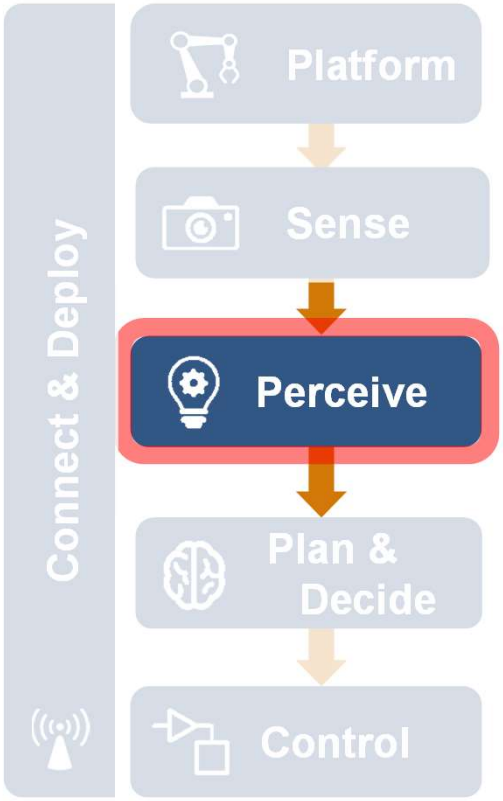
- 支持通用传感器
- 图像分析
- 图像增强
- 可视化点云
- 应用

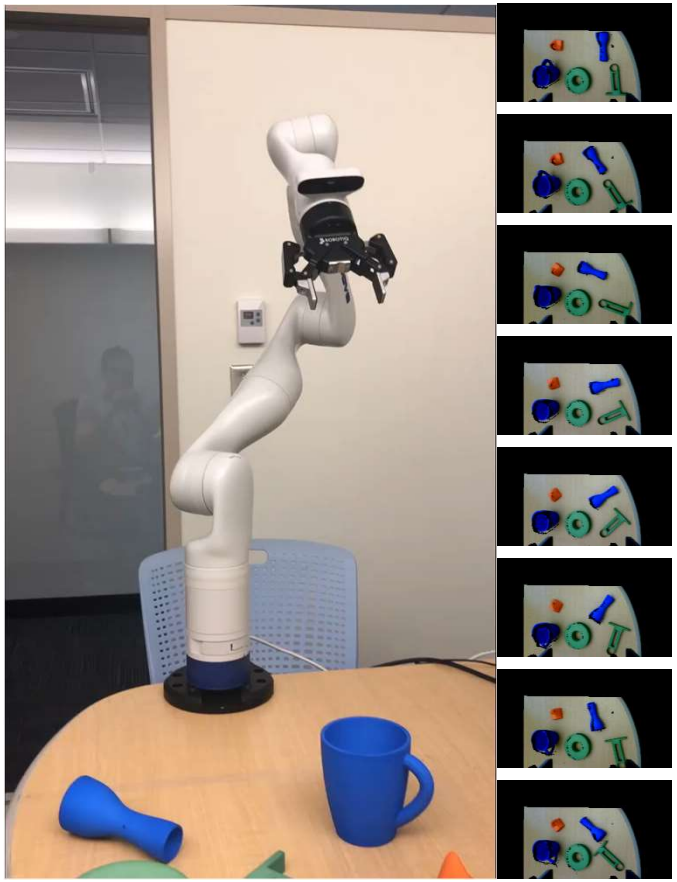


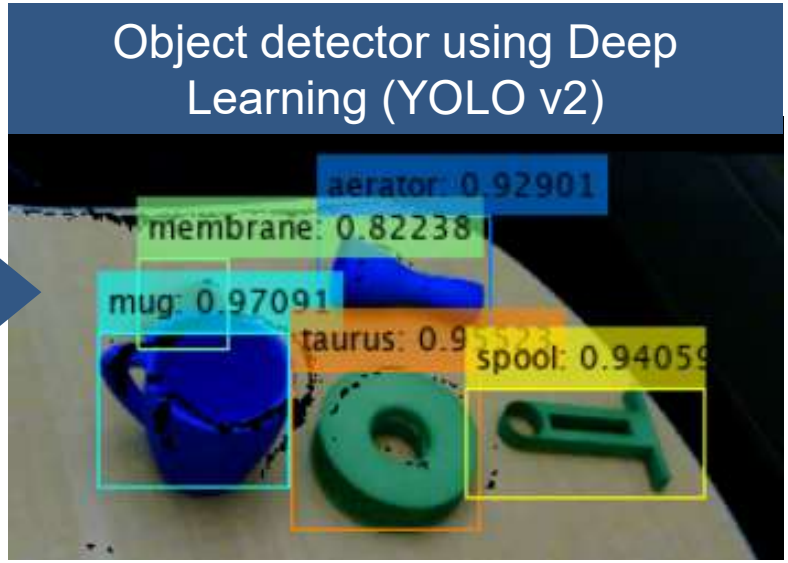


感知
深度学习用于目标分类

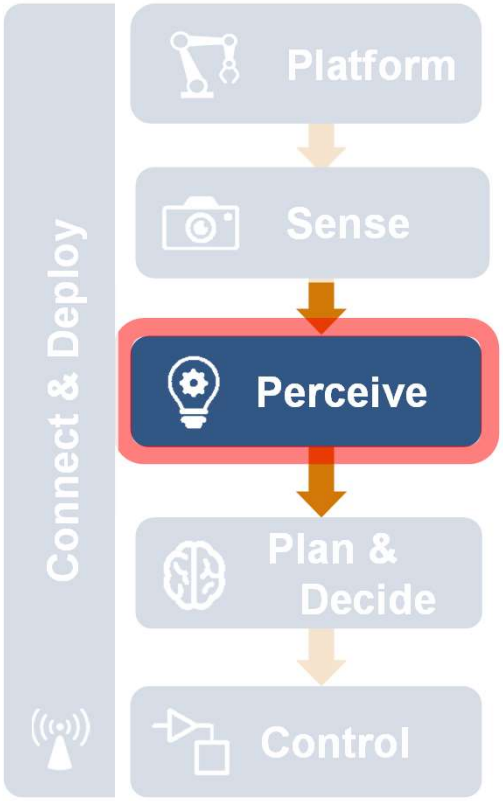
Deep Learning Toolbox

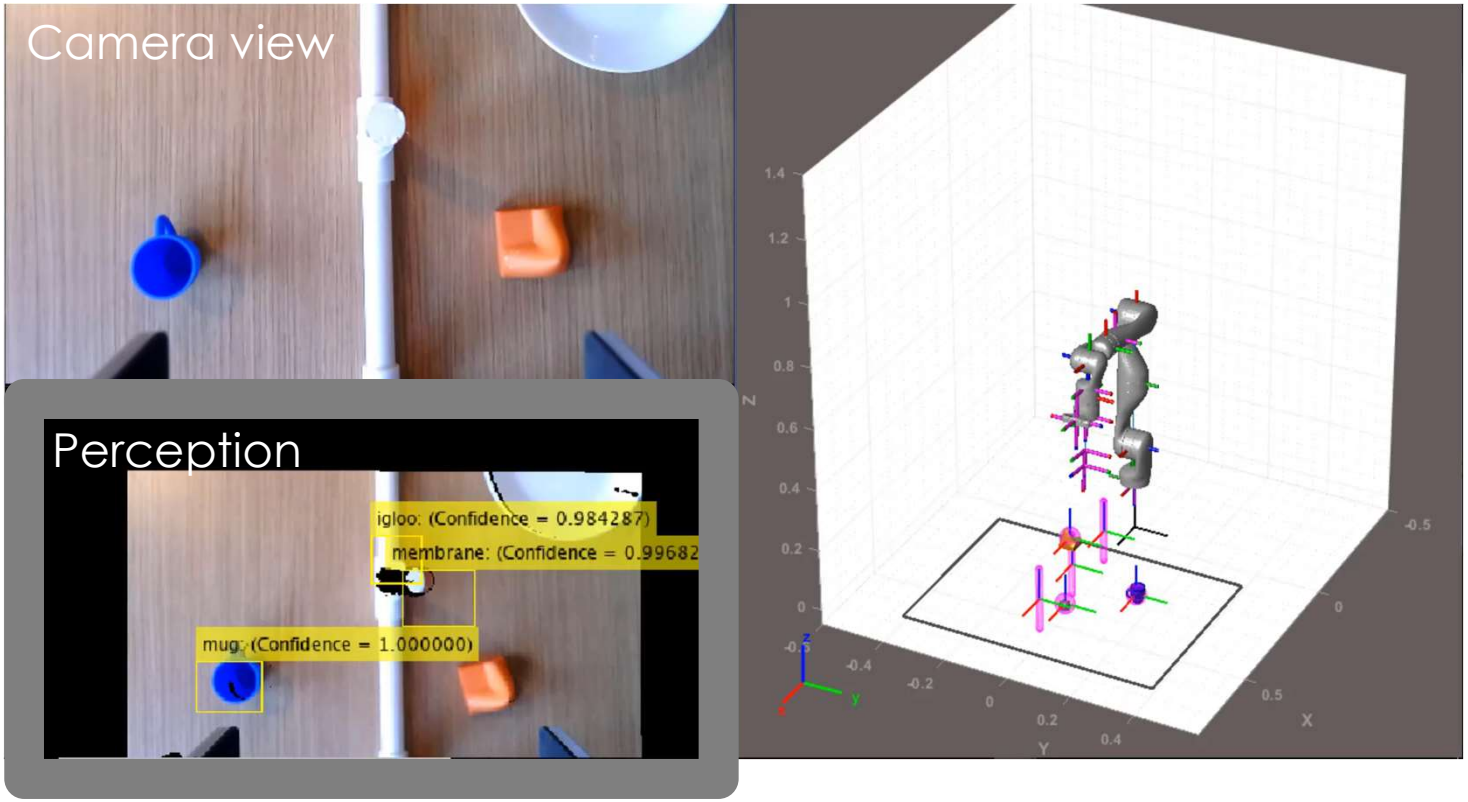






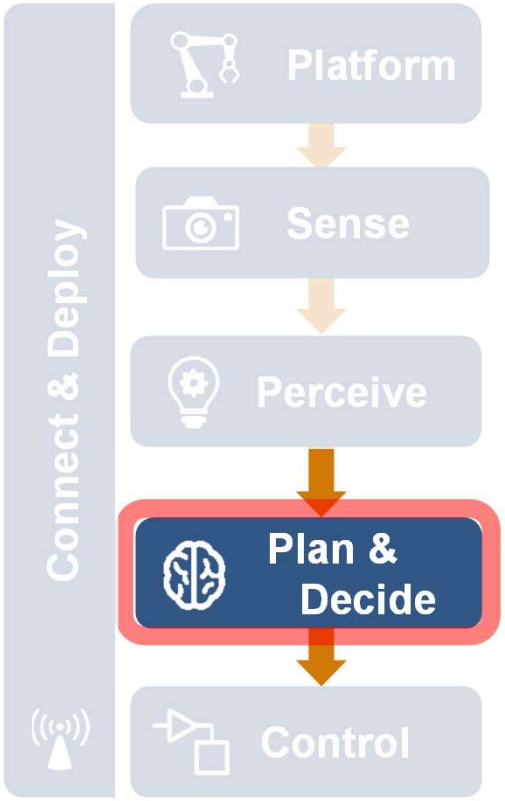
感知
目标分类


Connect & Deploy
Platform
Sense
Perceive
Plan & Decide
Control


Camera view
Perception
igloo: (Confidence = 0.984287)
membrane: (Confidence = 0.99682
mug: (Confidence = 1.000000)

运动规划


Initial Pose X(t0)
Final Pose X(tf)
Joint Limits
Obstacles
Motion Planner
Joint Trajectories Q(t)


Connect & Deploy
Platform
Sense
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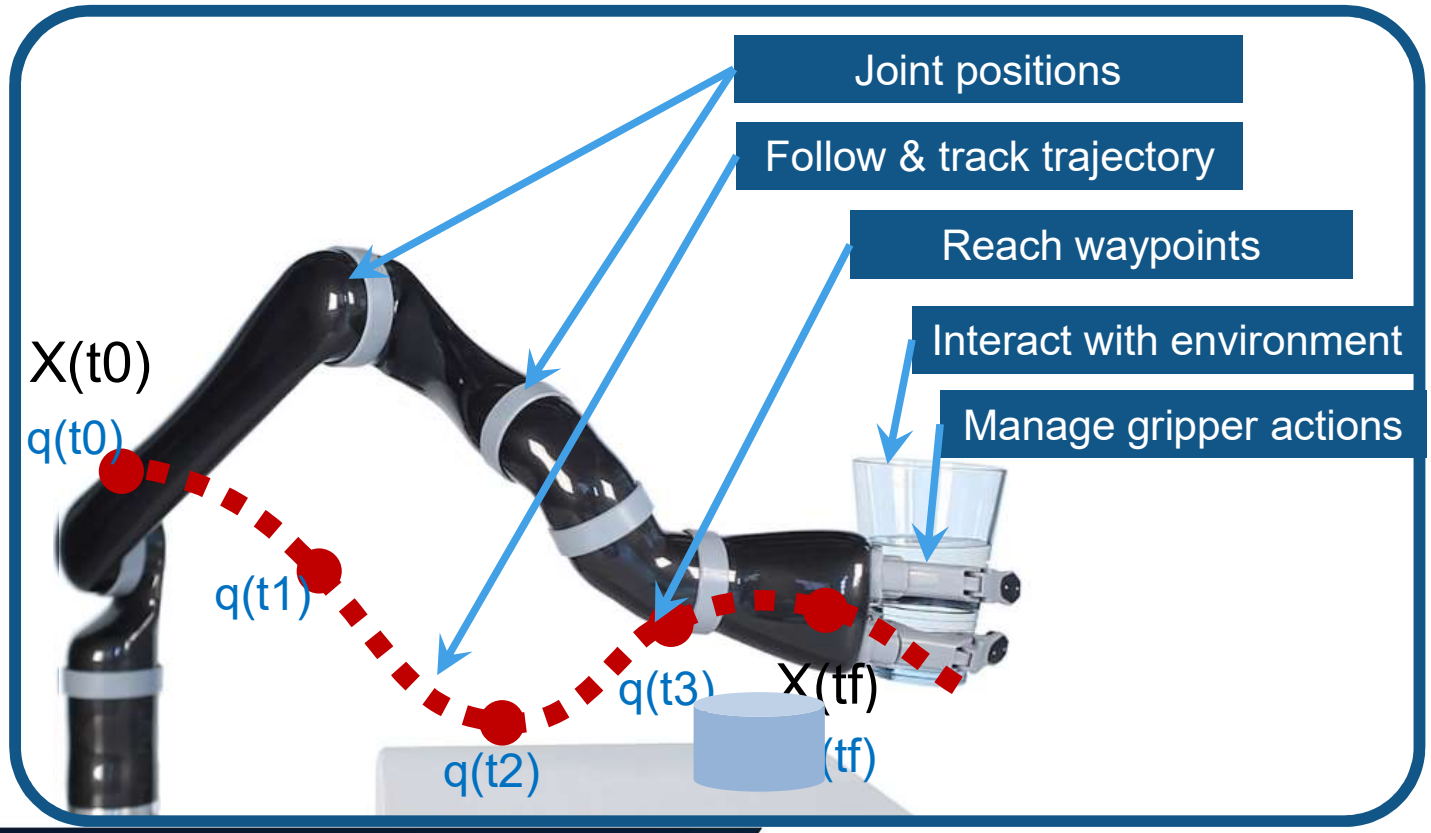
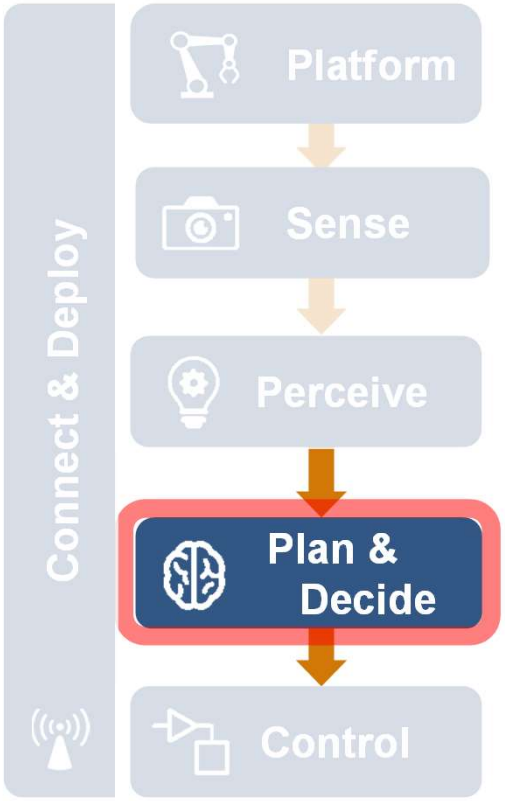

Joint positions
Follow & track trajectory
Reach waypoints
Interact with environment
Manage gripper actions
X(t0)
q(t0)
q(t1)
q(t2)
q(t3)
X(tf)
(tf)

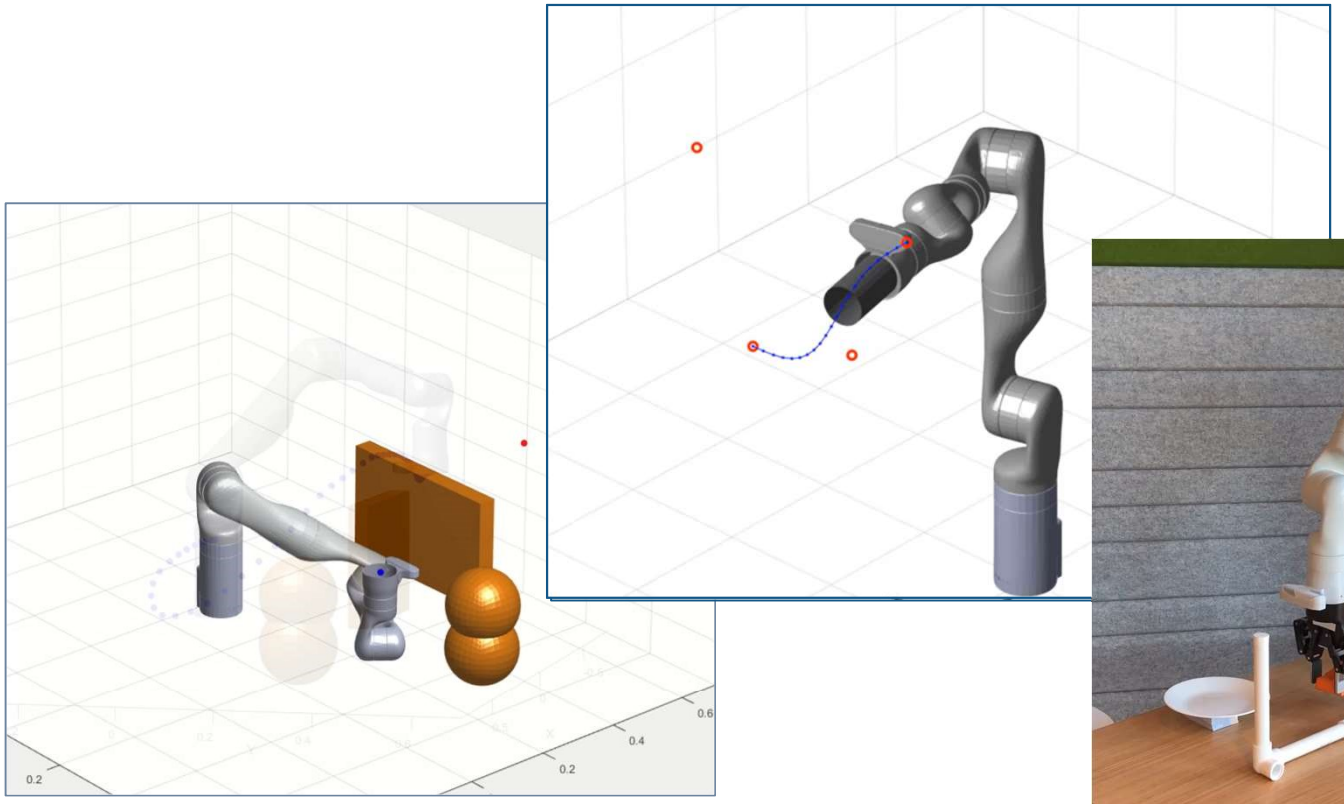
运动规划

路径规划+轨迹生成+轨迹跟随

Robotics System Toolbox

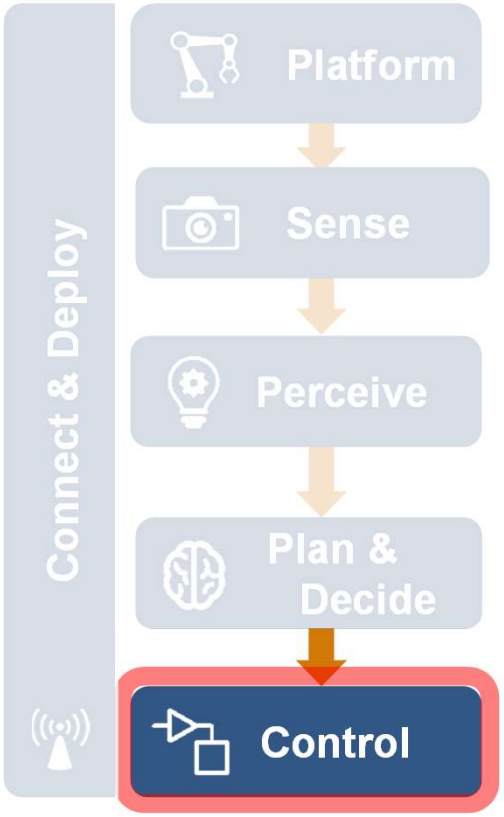
Model Predictive Control Toolbox

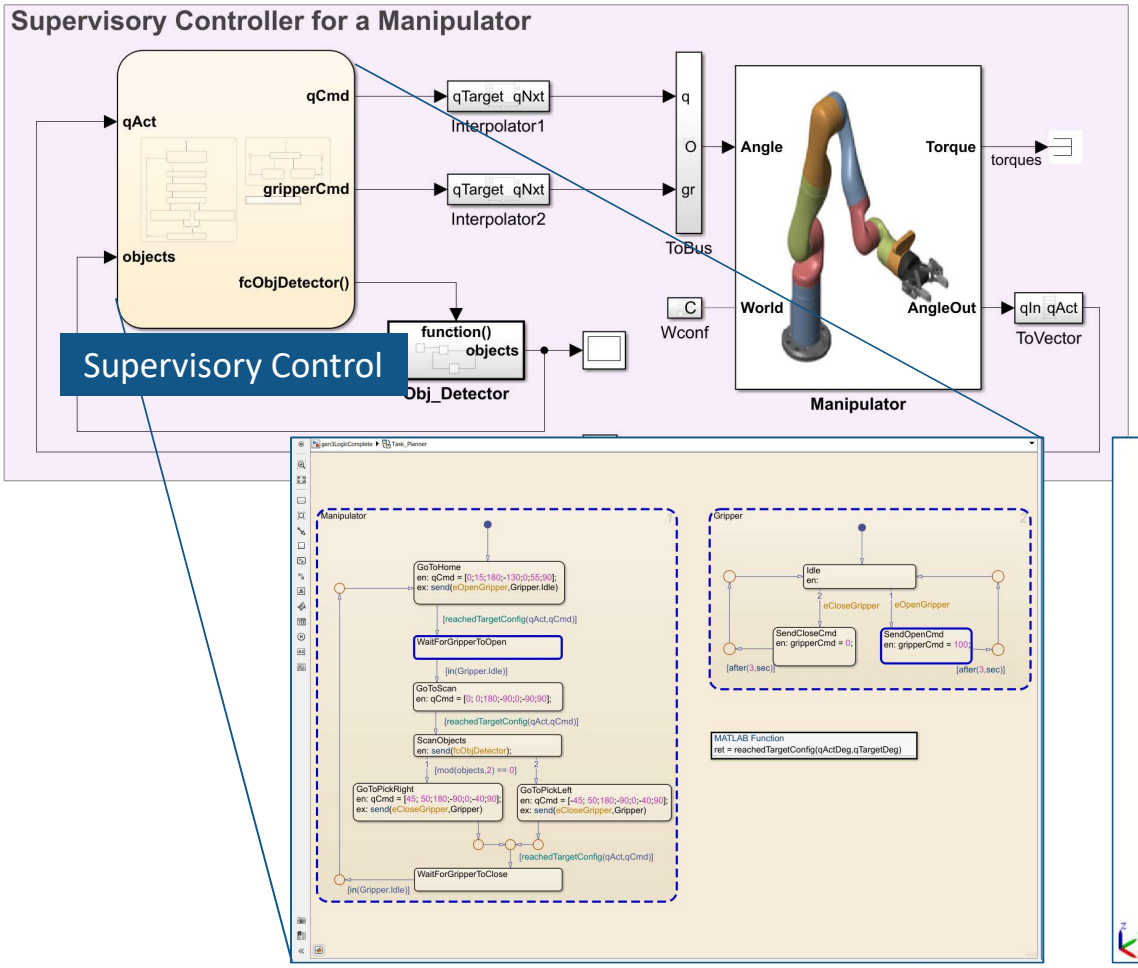


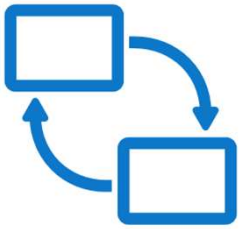


运动控制
决策逻辑

Stateflow





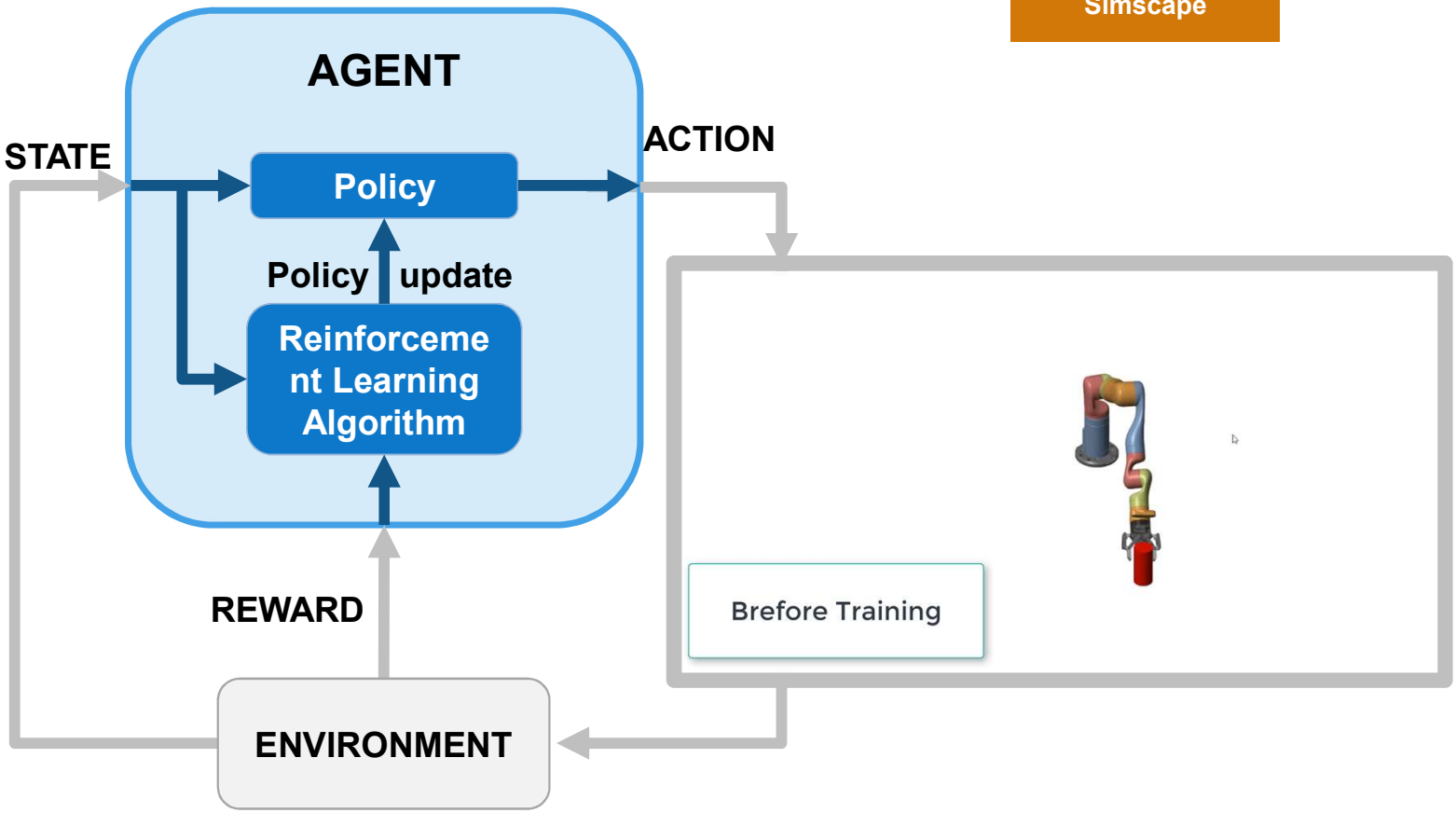


高级控制:强化学习

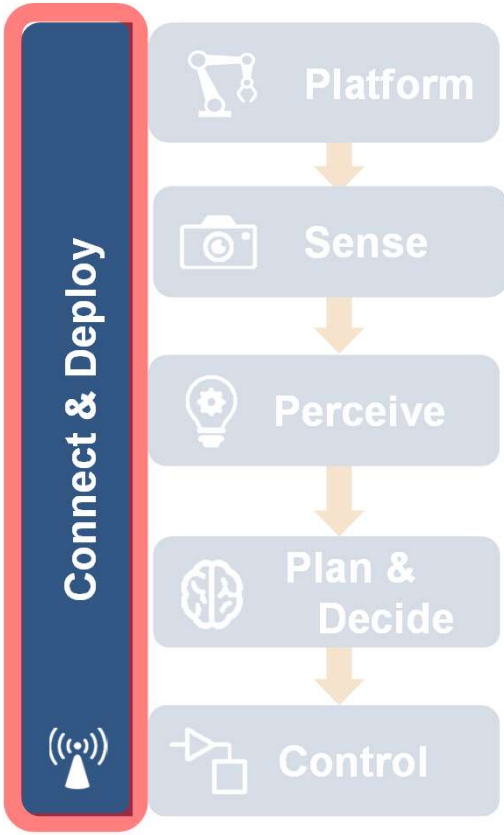
训练机器人到达目标物体

Reinforcement Learning Toolbox

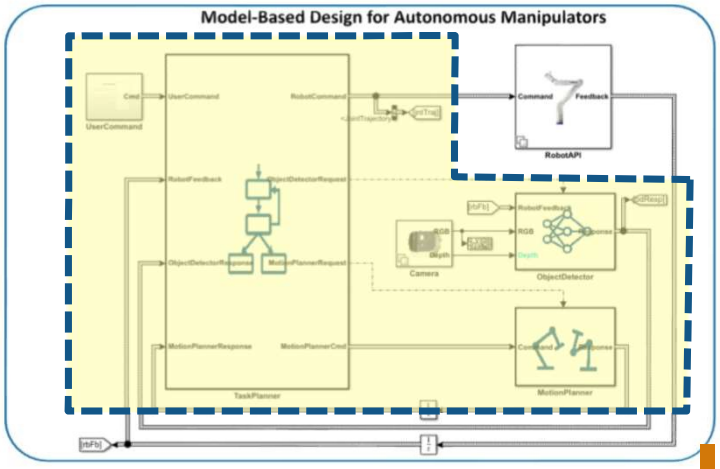
Simscape



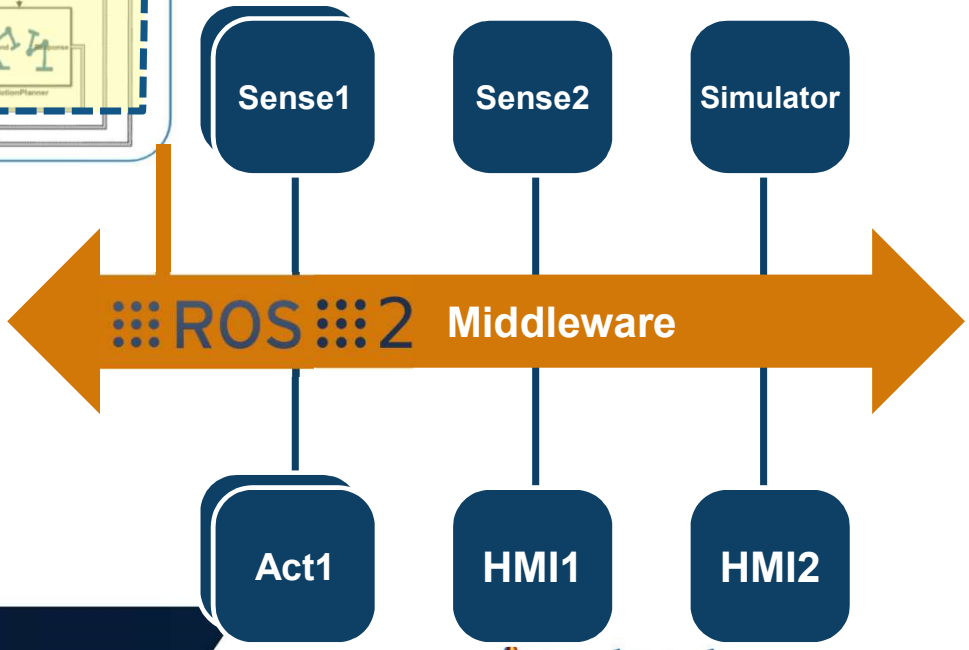
连接硬件
支持代码生成



ROS Toolbox



Application



连接硬件
支持代码生成

Stateflow

Connect & Deploy

Platform

Sense

Perceive

Plan & Decide

Control

HOST PC

SIMULINK

User Application
Video/image processing, perception, supervisory logic, high level control algorithms, trajectory planners, etc.

Kinova Vision System Object
GStreamer

Kinova System Object
Supports Interpreted & Code Generation modes

Use publisher/subscriber capabilities in Simulink to connect to ROS topics

Jetson Xavier (Ubuntu 18.04)

NVIDIA

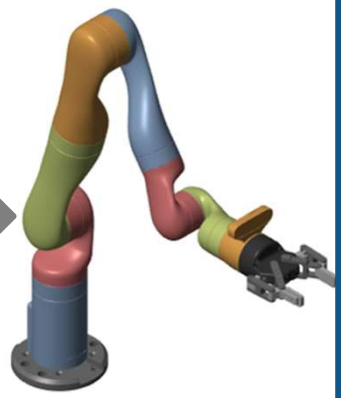
2 (Bouncy)

Node2
User Application

Node3
User Application

Node1
Kinova System Object
Kortex API

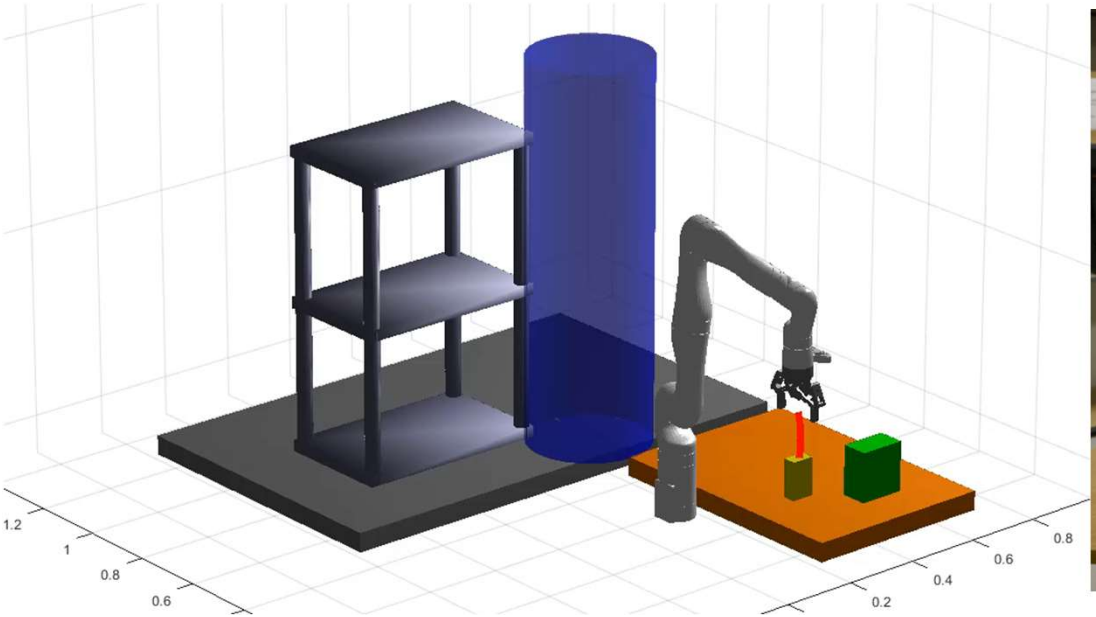
Ethernet



Simulink to ROS2 stand-alone node deployment

Allows multi-thread, multi-core and pseudo real-time

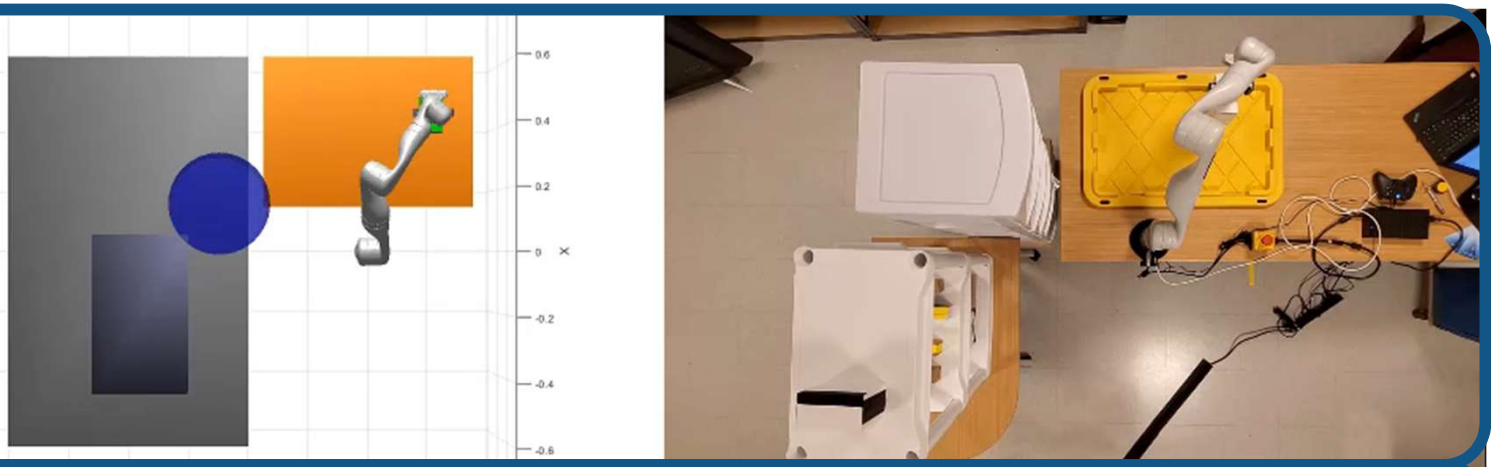
使用相同的参考工作流程
仓库装卸(储存架)



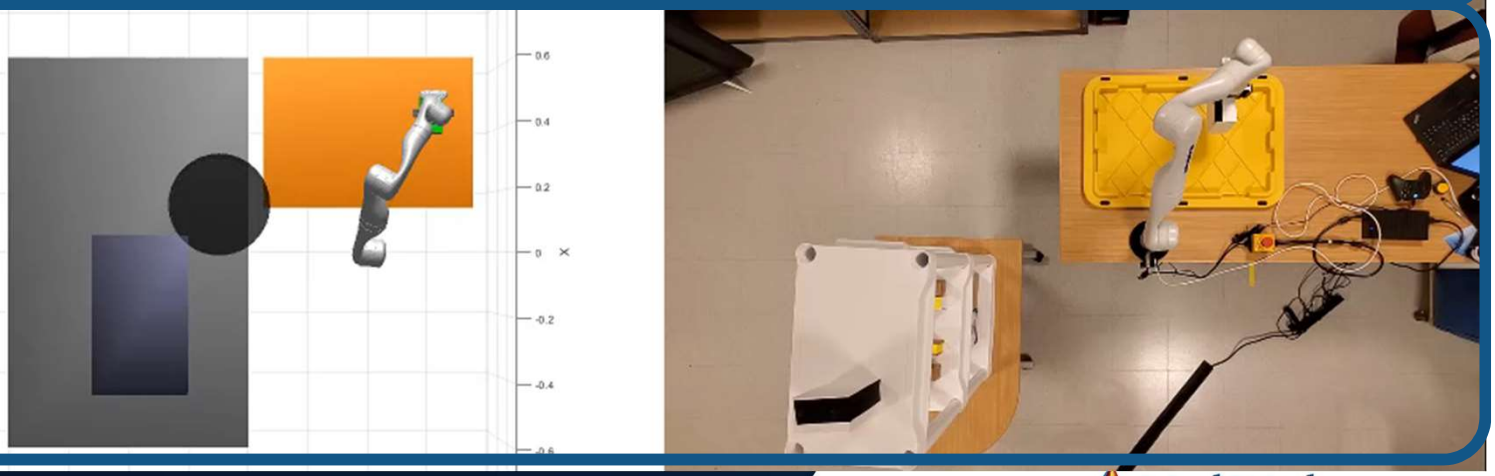
这个示例的工作流强调了在MATLAB中使用Robotics System Toolbox的碰撞检测算法、非线性MPC和Stateflow状态机

使用相同的参考工作流程
仓库装卸(储存架)

避障 **ON**
(障碍物显示为蓝色)



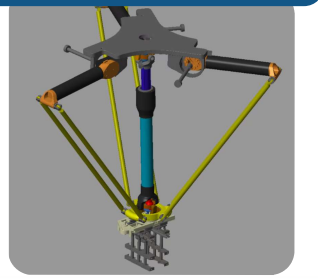
避障 **OFF**
(黑色显示障碍物，以供参考)



使用相同的参考工作流程

Delta机械手进行自动零件分拣

Platform

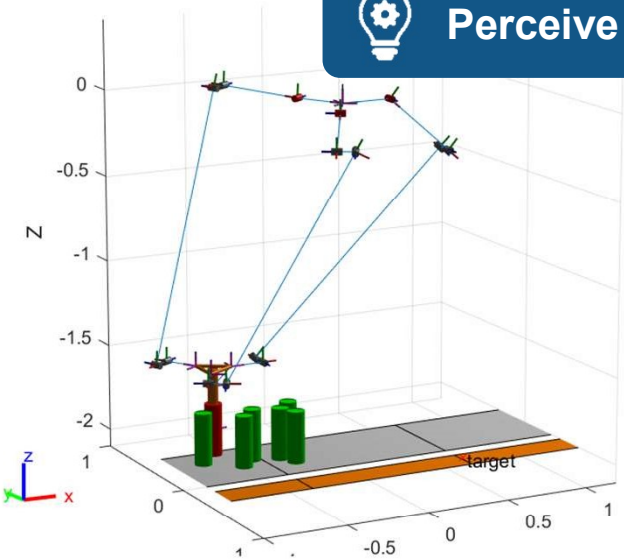


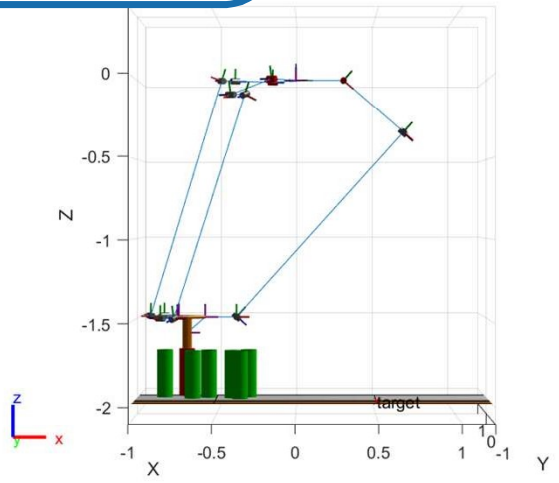
KRONES

Connect

Sense

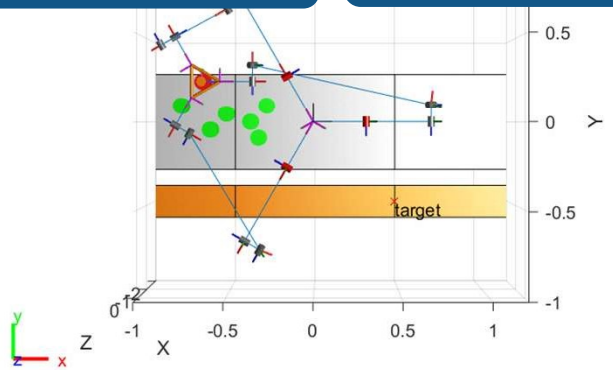
Perceive





Plan & Decide

Control



讨论的主题：

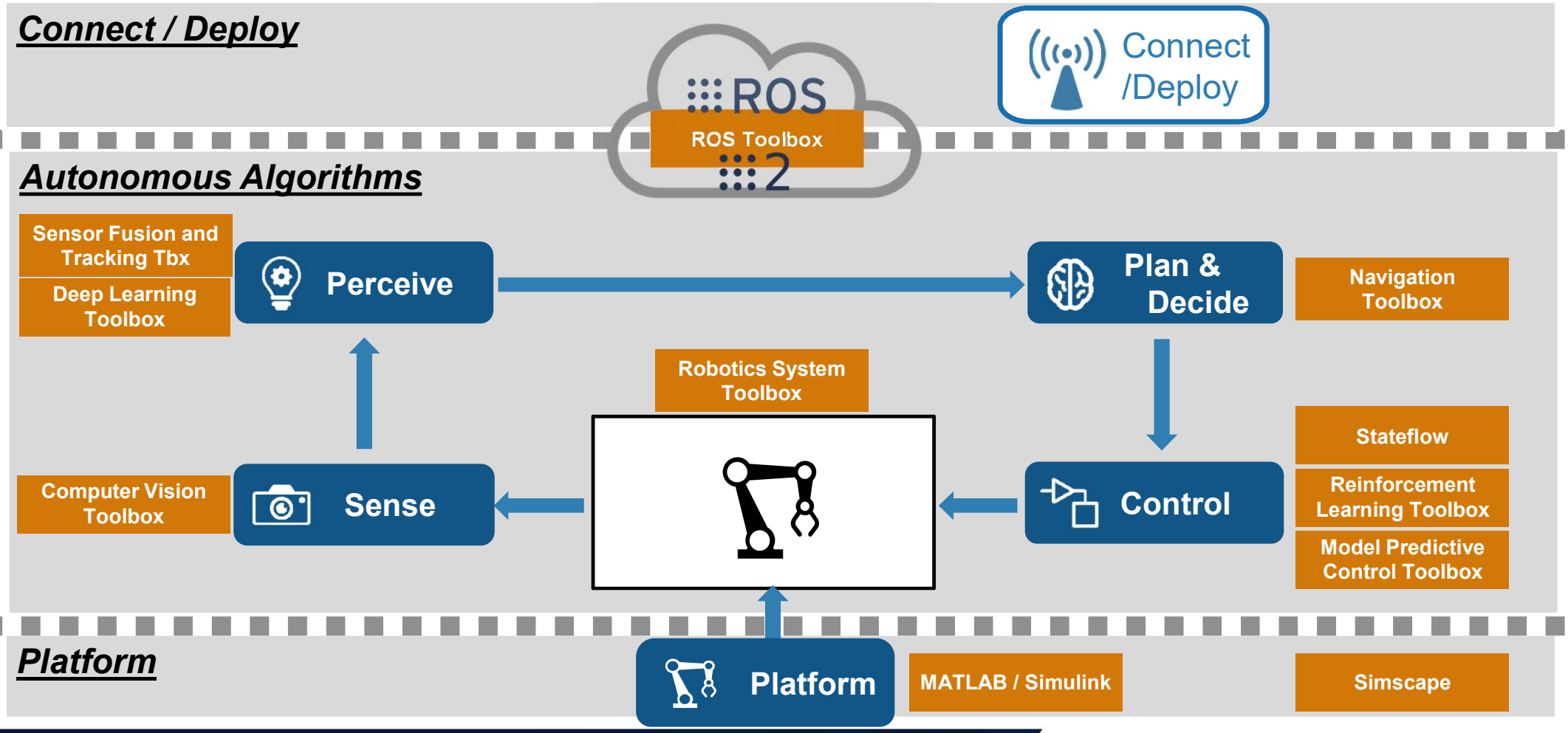
自主系统发展的趋势

案例研究：分拣机器人的应用

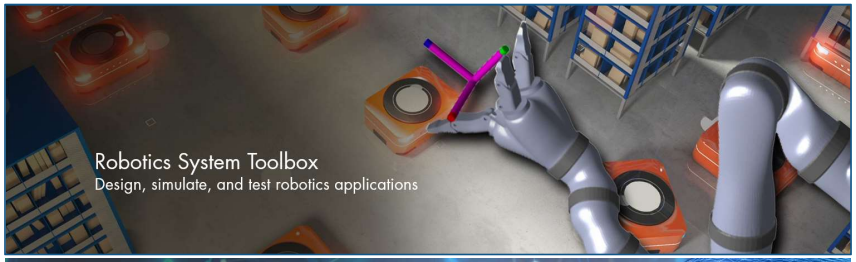
自主系统的基于模型的设计

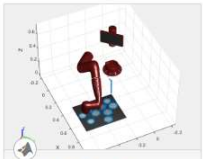
用户案例
结束语

完整的基于模型的设计流程



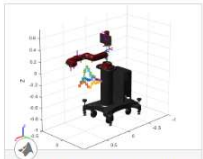
更多的技术资源





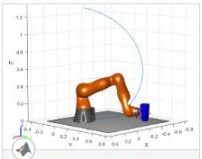
Trajectory Control Modeling With Inverse Kinematics

This Simulink example demonstrates how the Inverse Kinematics block can drive a manipulator along a specified



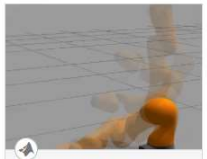
Manipulator Shape Tracing in MATLAB and Simulink

Trace a predefined 3-D shape in space. Following a smooth, distinct path is useful in many robotics applications such as welding,



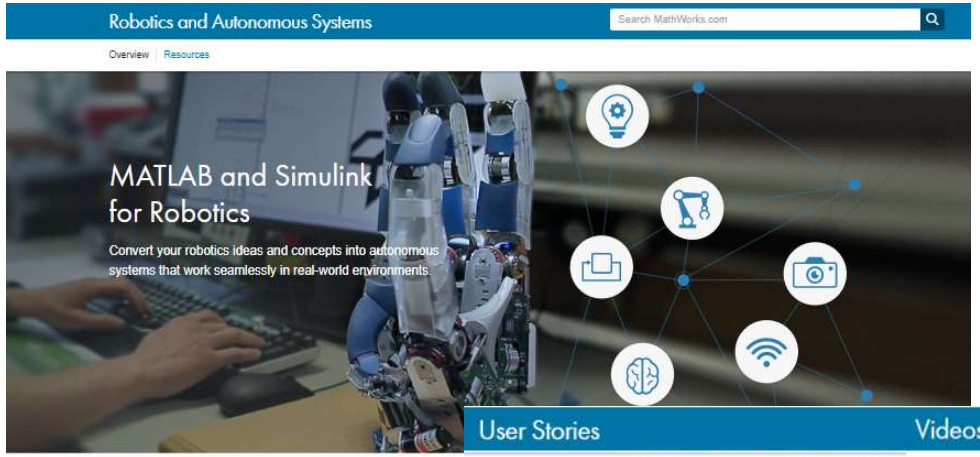
Plan a Reaching Trajectory With Multiple Kinematic Constraints

Use generalized inverse kinematics to plan a joint-space trajectory for a robotic manipulator. It combines multiple constraints to generate a



Control LBR Manipulator Motion Through Joint Torque Commands

Given a set of desired joint configuration waypoints and a torque-controlled manipulator, this example shows how to implement



User Stories

3T Develops Robot Emergency Braking Sys Based Design
3T modeled an emergency brake controller for verified the design, and generated defect-free implementation.

Clearpath Robotics Accelerates Algorithm I Industrial Robots
Clearpath Robotics shortens development time perception, computer vision, fleet managemen for industrial robots.

German Aerospace Center (DLR) Robotics Center Develops Autonomous Humanoid R Based Design
DLR developed advanced algorithms, generat and real-time operation, and automated senso armed robot.

HEBI Robotics Enables Rapid Development Algorithms for Robots Assembled from Sm
HEBI Robotics created a MATLAB based API accelerates the development of real-time contr powered by HEBI actuators.

Mitsubishi Heavy Industries Develops Robo Nuclear Fuel Debris
MHI used Model-Based Design to develop higl software for a seven-meter, multi-axis robotic a Daiichi nuclear power station clean-up effort.

Videos and Webinars

What Is Robotics System Toolbox? 1:56
Design, simulate, and test robotics applications.
Date: 13 Mar 2015

Path Planning and Navigation for Autonomous 2:20
Simplify the complex tasks of robotic path planning Simulink. This demonstration walks through how to using just three components: a path,...
Date: 31 Oct 2017

Simulink Blocks for Robot Manipulators and Sa 2:58
Use Simulink blocks to design, simulate, and imple and perform safe trajectory tracking control.
Date: 12 Jul 2018

Designing Robot Manipulator Algorithms 28:21
Accelerate the design of robot manipulator algorith Toolbox functionality and integrating robot models test manipulation tasks.

Robotics: Tools and Workflow 6:13
Professor Peter Corke describes why MATLAB and discusses using MathWorks tools for robot
Date: 1 Nov 2016

Control LBR Manipulator Motion Through Jo
Solve inverse and forward dynamics for RigidBo

MATLAB EXPO

结束语

工业机器人应用发展的挑战性

- Multi-domain Expertise
- Complexity of Algorithms
- End-to-End workflows
- Technical Depth and System Stability

开发基于模型设计的软件

- Fast Iterations
- Strong Focus on Simulation

端到端工作流程用于工业机器人应用开发

- Platform
- Sense
- Perceive
- Plan & Decide
- Control