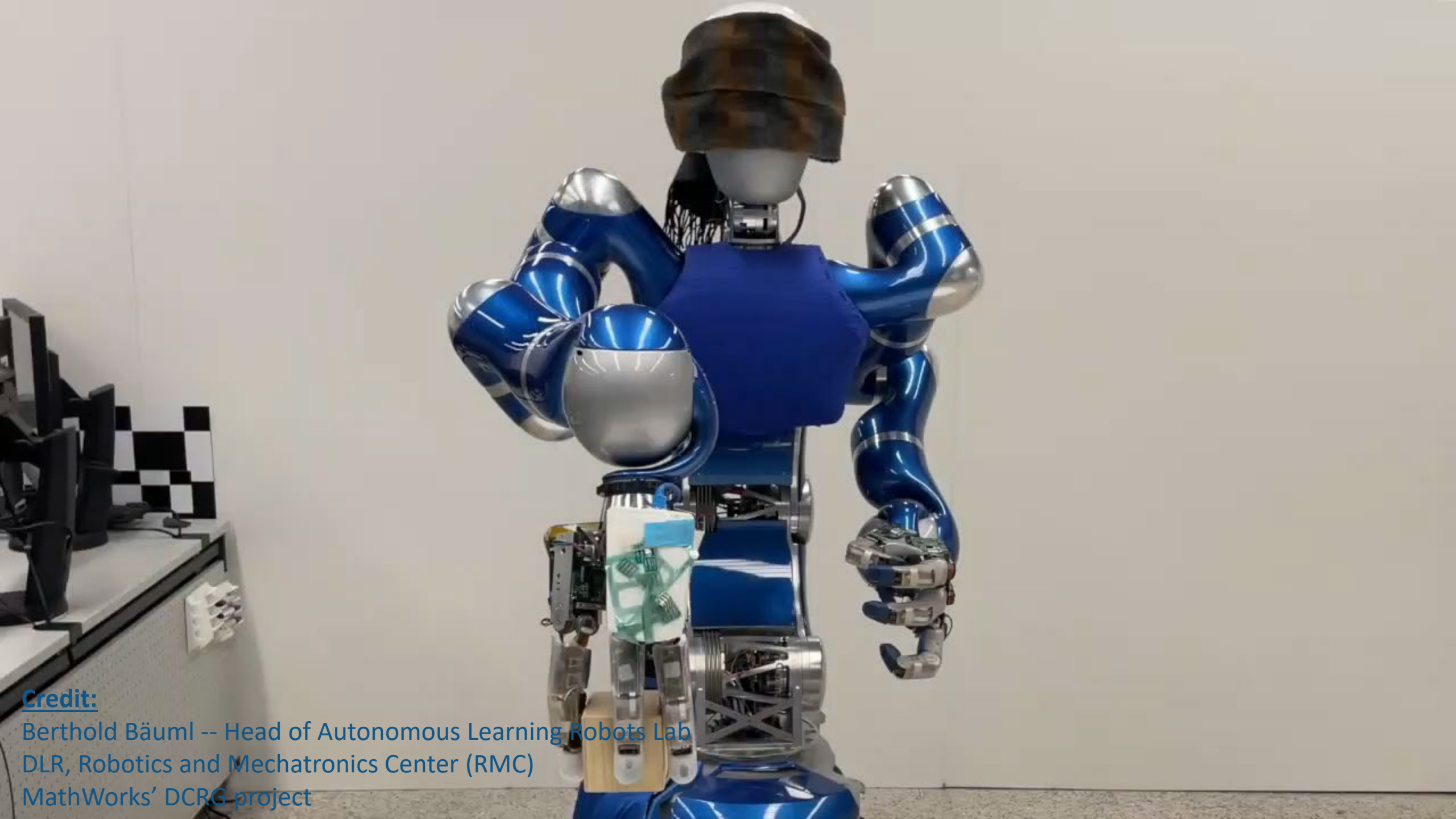


# MATLAB EXPO

## MATLAB AI 应用赋能机器人自主化

王希博, MathWorks



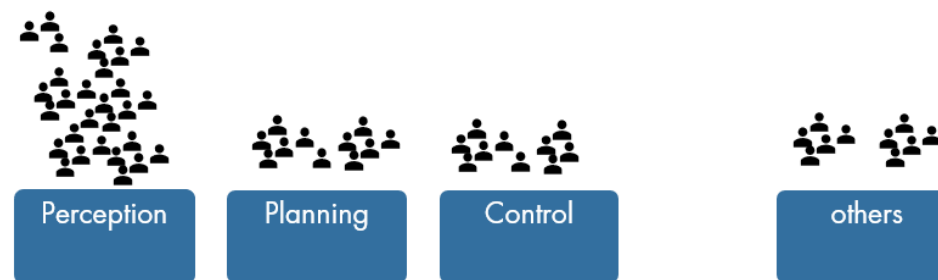


Credit:  
Berthold Bäuml -- Head of Autonomous Learning Robots Lab  
DLR, Robotics and Mechatronics Center (RMC)  
MathWorks' DCRG project

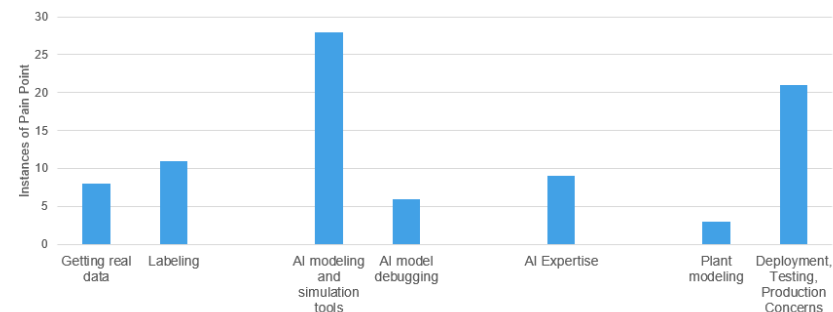
# 用户调研 – 对AI感兴趣的机器人专家如何使用AI



## AI 在机器人领域有哪些应用？



## 工程师们遇到了哪些挑战？



## 商业机器人客户：AI 在机器人领域有哪些应用？

Perception

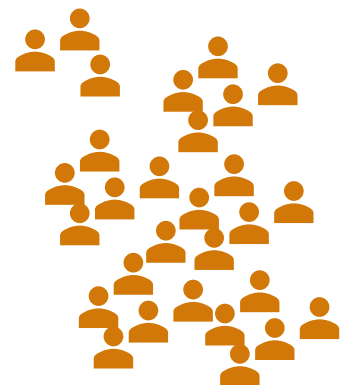
Planning

Control

others

# 商业机器人客户将AI更多地用于感知

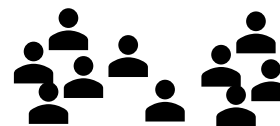
为什么？



Perception



Planning



Control

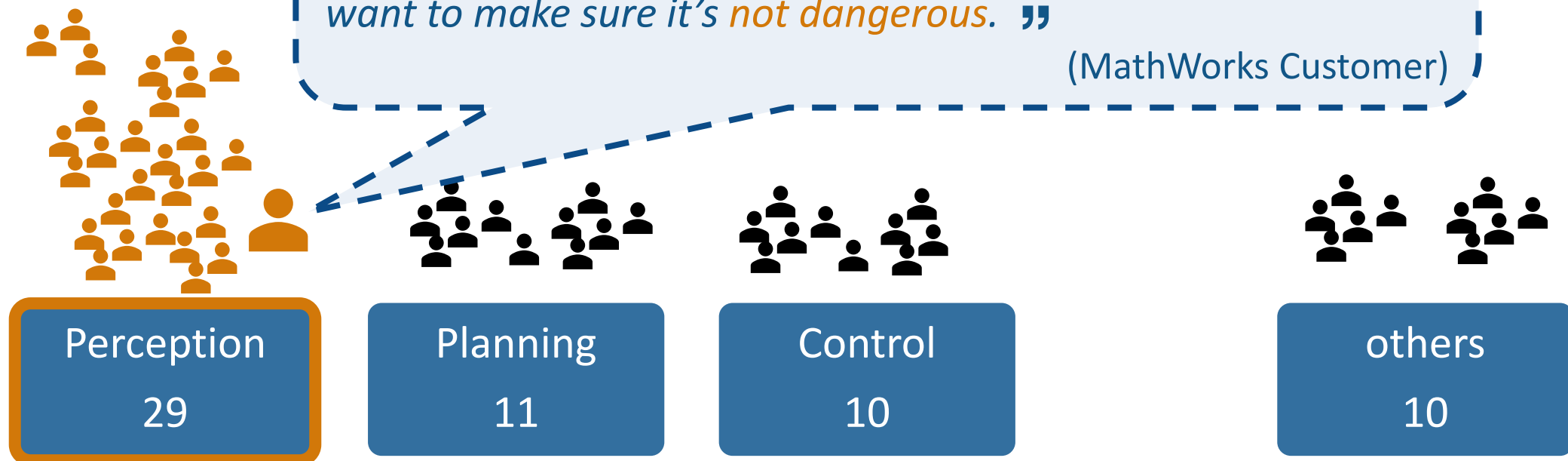


others

# 安全性、鲁棒性和认证对生产至关重要。 传统算法比 AI 算法更有优势

“ We want to limit whatever the neural net – or even (for) teleop.... whatever action is commanded there. We want to make sure that it[Robot]’s *not stupid*. Or even if it’s stupid, we want to make sure it’s *not dangerous*. ”

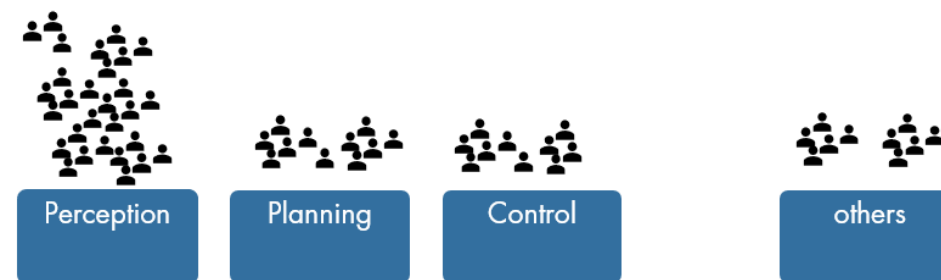
(MathWorks Customer)



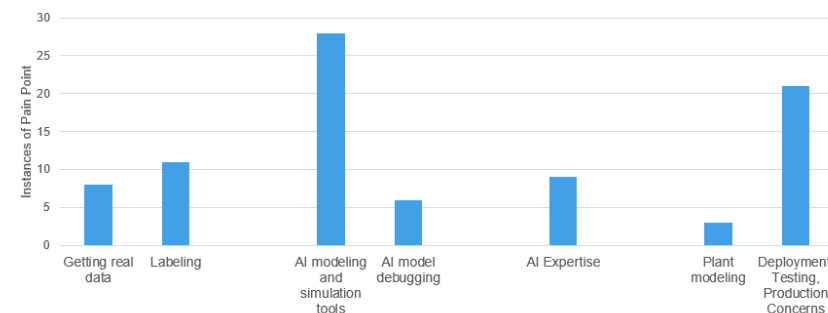
# 用户调研 – 对AI感兴趣的机器人专家如何使用AI



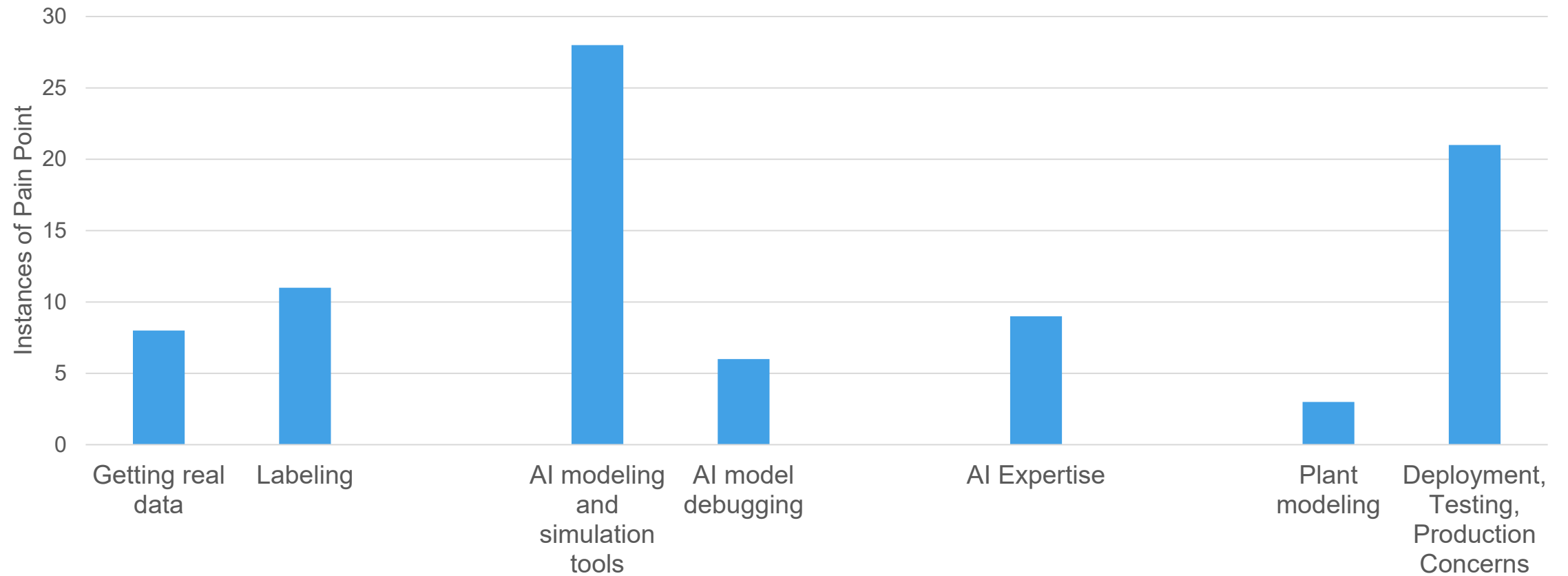
## AI 在机器人领域有哪些应用？



## 工程师们遇到了哪些挑战？

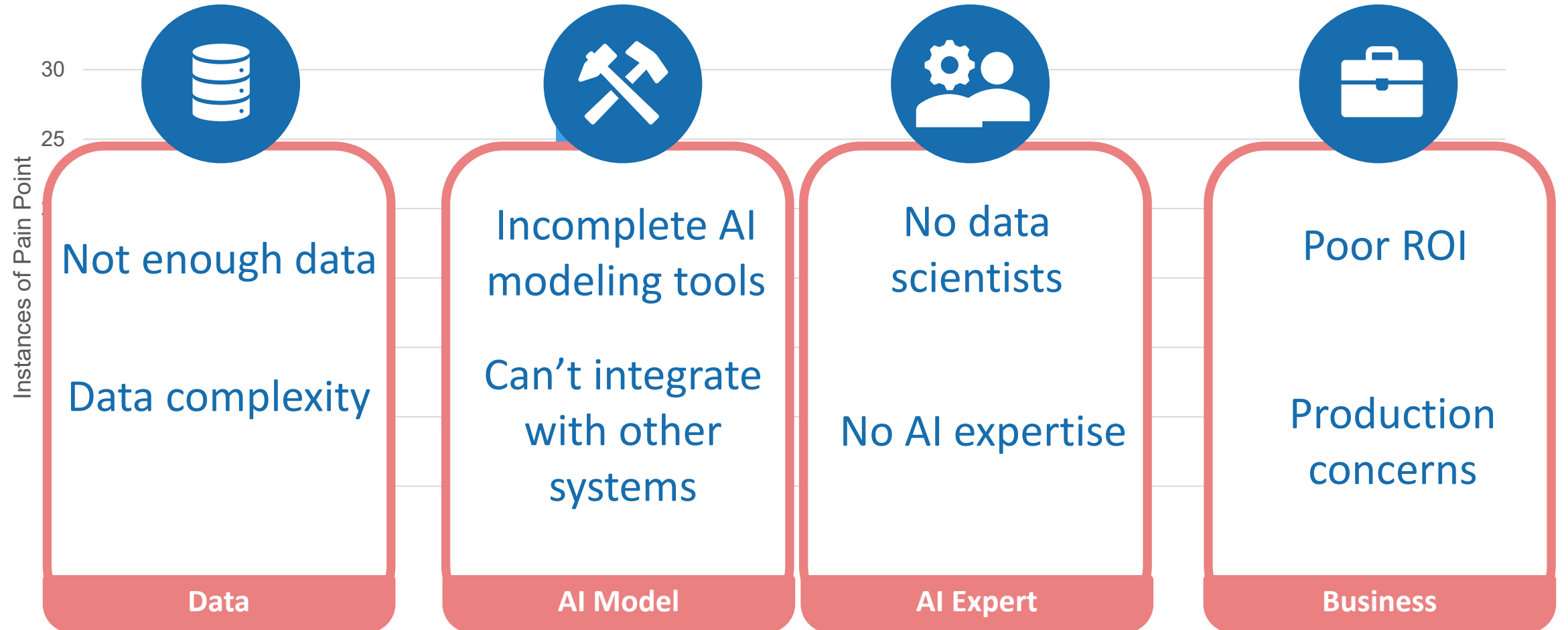


# 工程师们遇到了哪些痛苦和挑战？

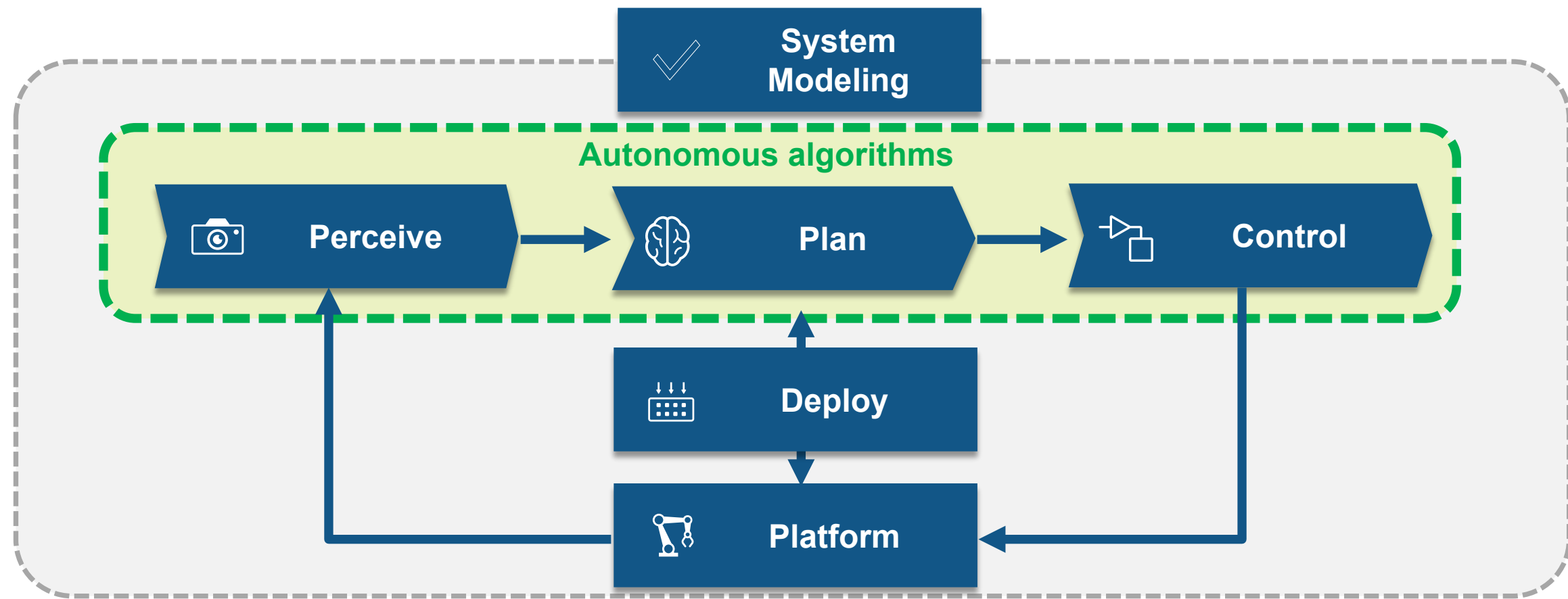




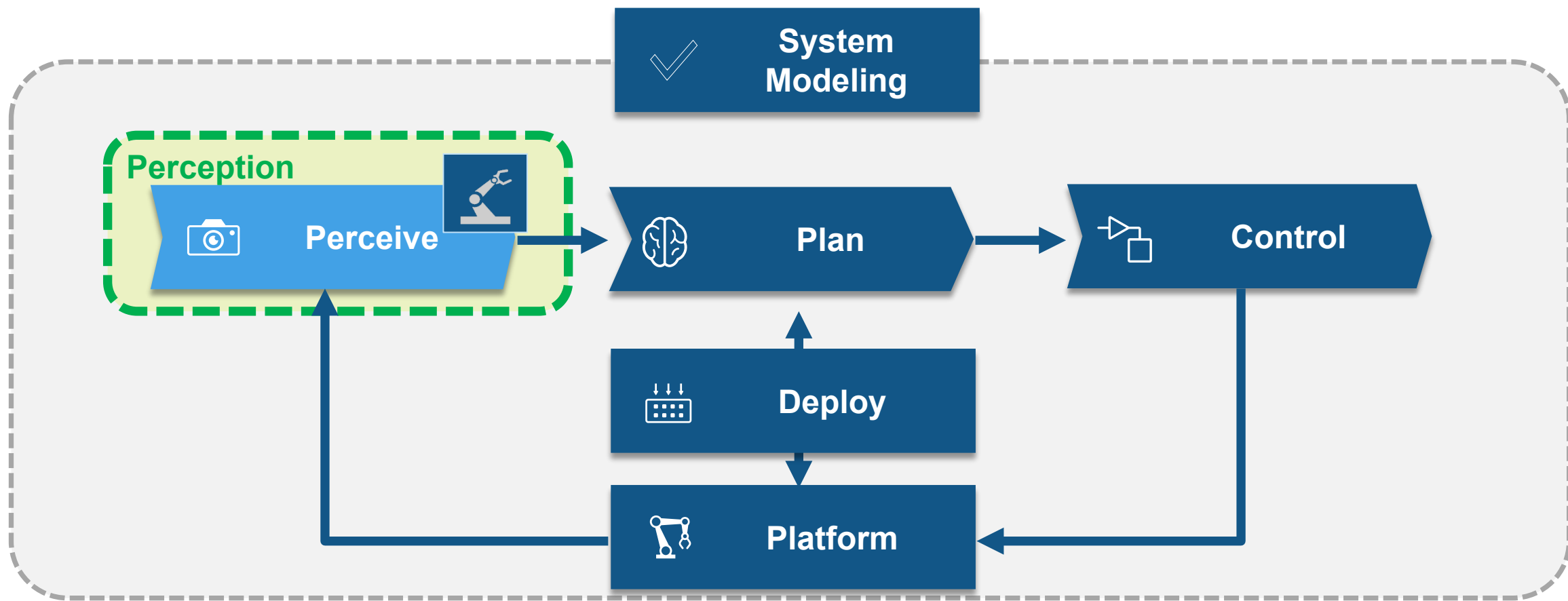
# 工程师们遇到了哪些痛苦和挑战？



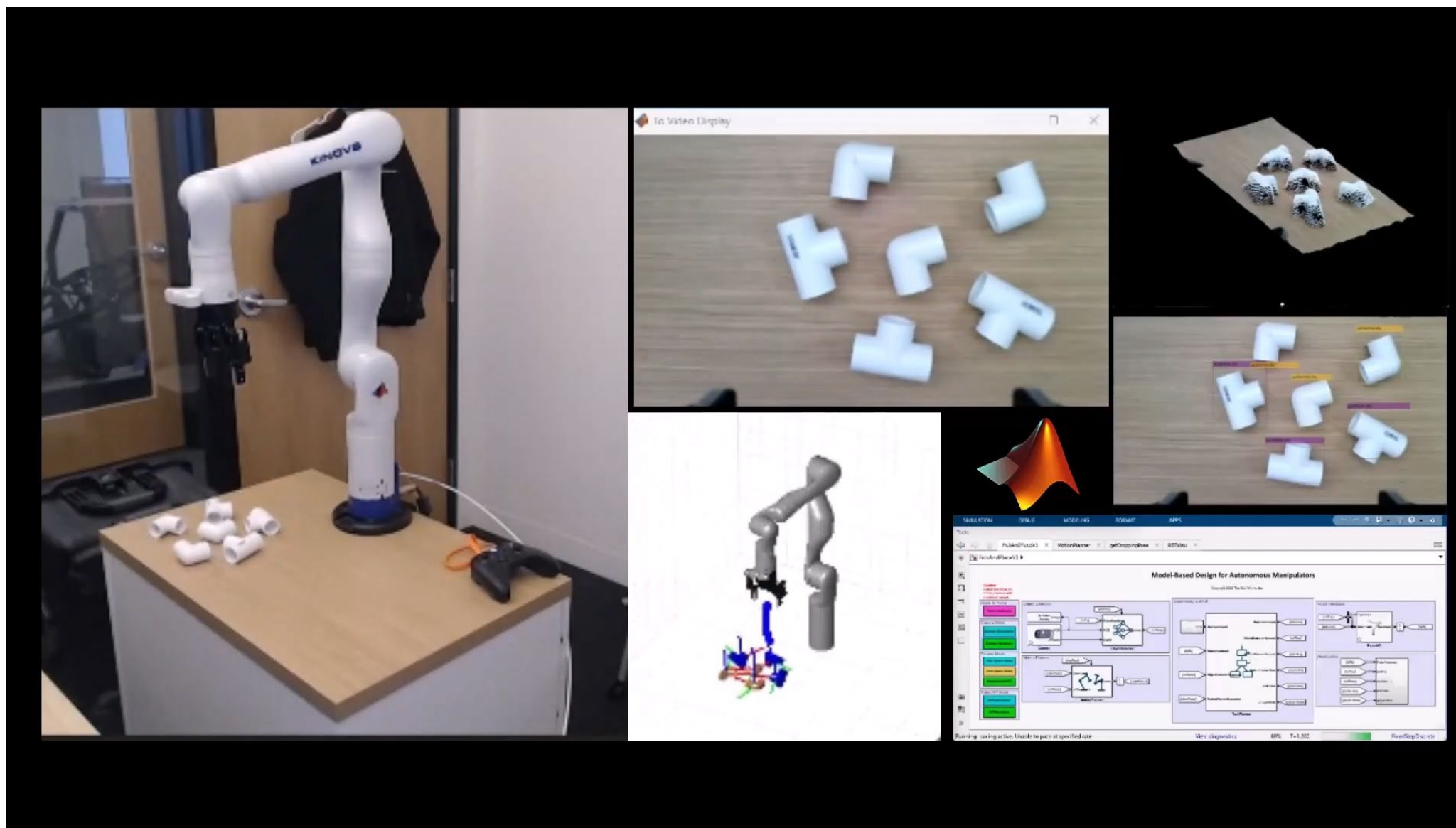
# 自主系统设计工作流程



# 自主系统设计工作流程



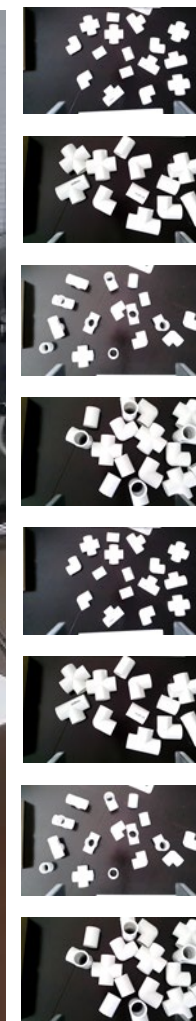
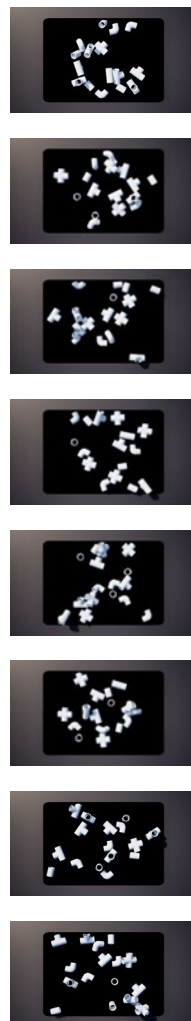
# 使用协作机器人开发分拣应用





# 如何获取训练数据?

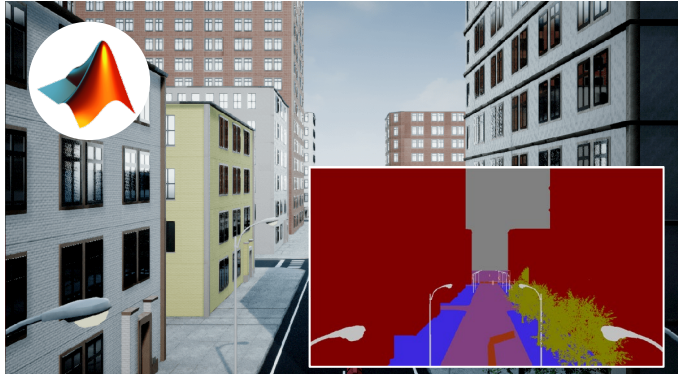
Simulink 3D Animation  
Robotics System Toolbox  
Computer Vision Toolbox



Synthetic data generation with simulator

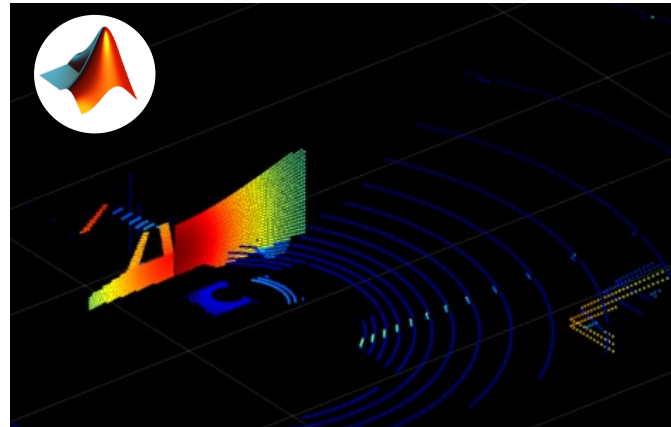
Data acquisition with hardware

# 生成合成数据以改进数据集



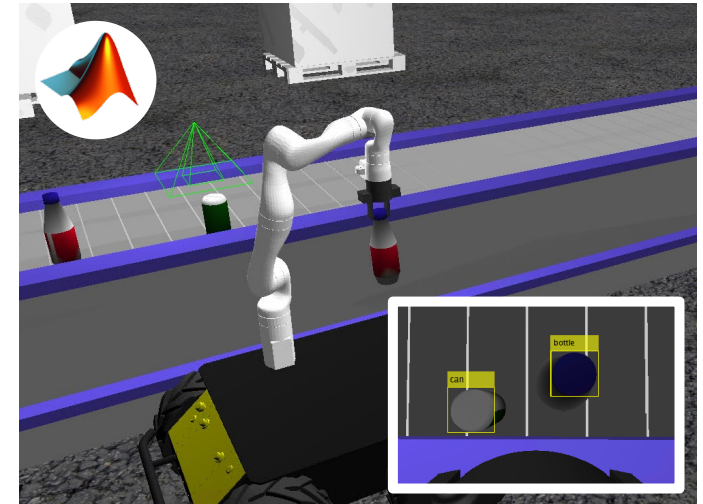
## Semantic Segmentation from Unreal for UAV

UAV Toolbox  
Simulink



## Lidar Sensor Model: Simulate lidar sensor and generate point cloud data

Lidar Toolbox

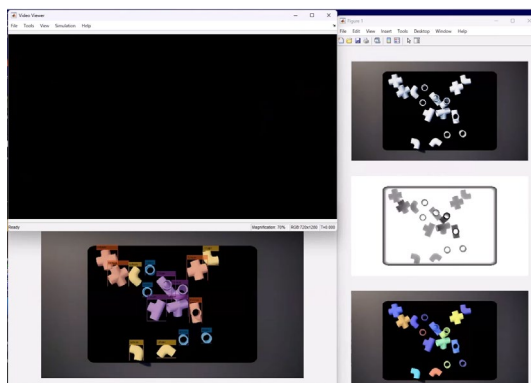


## Gazebo Co-simulation with a Pretrained Deep Learning Model to Detect Recyclable Parts

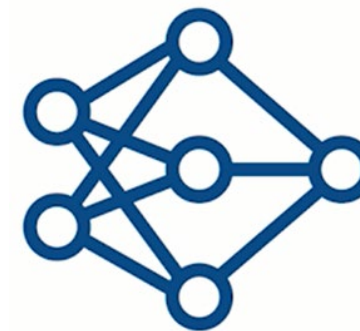
Robotics System Toolbox  
ROS Toolbox

# 自动化标注工具可为您节省数周至数月时间

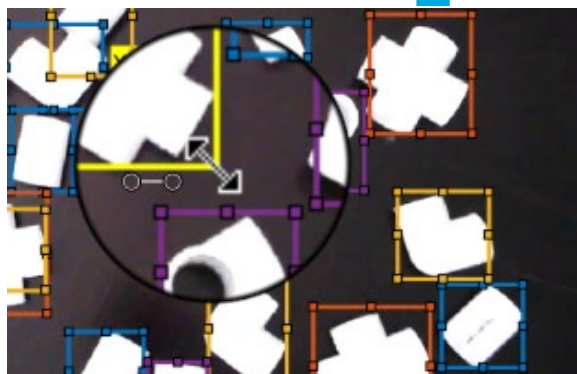
Computer Vision Toolbox  
Deep Learning Toolbox  
Simulink 3D Animation



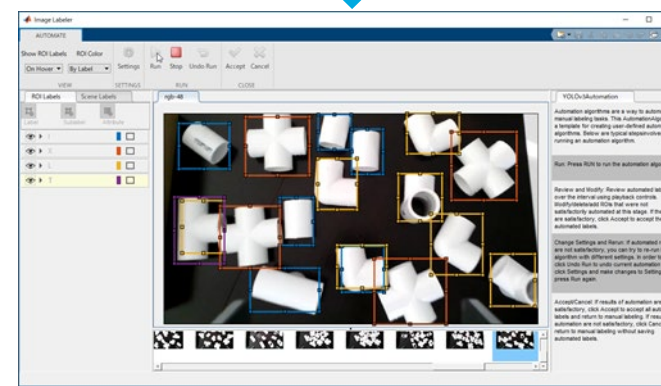
Synthetic data generation with CAD models



Train object detector



Correct wrong labels



Automated labeling with actual images

# 以成套算法和预训练模型为起点

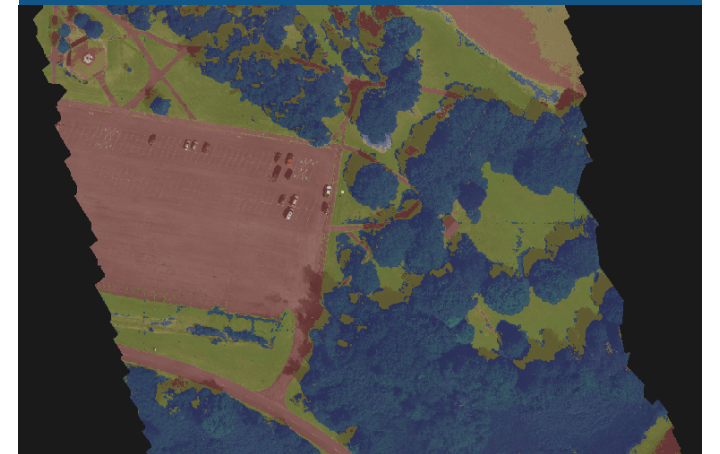
## Object Detection with YOLOv4



## Instance Segmentation with Mask R-CNN



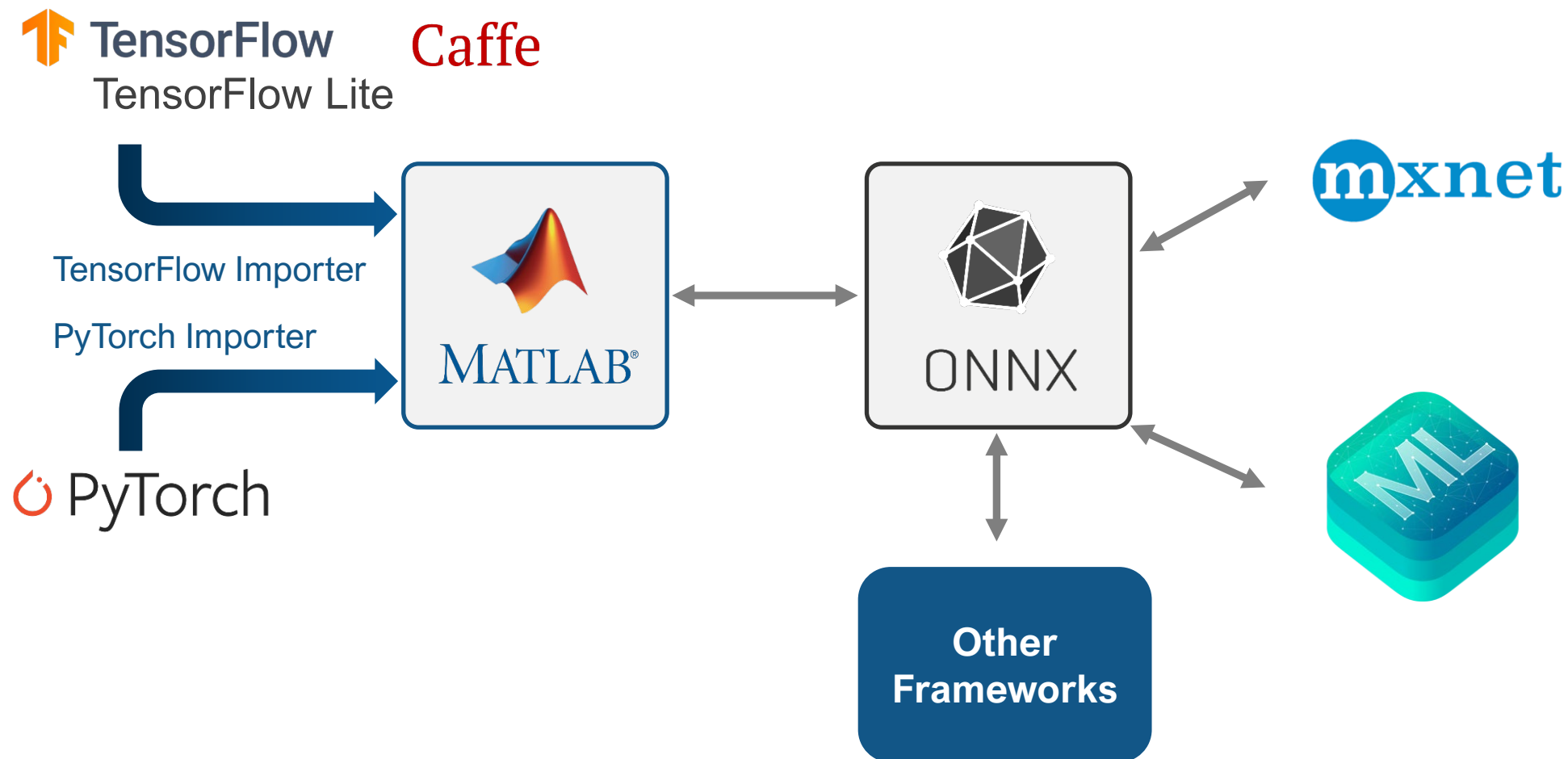
## Semantic Segmentation with U-Net



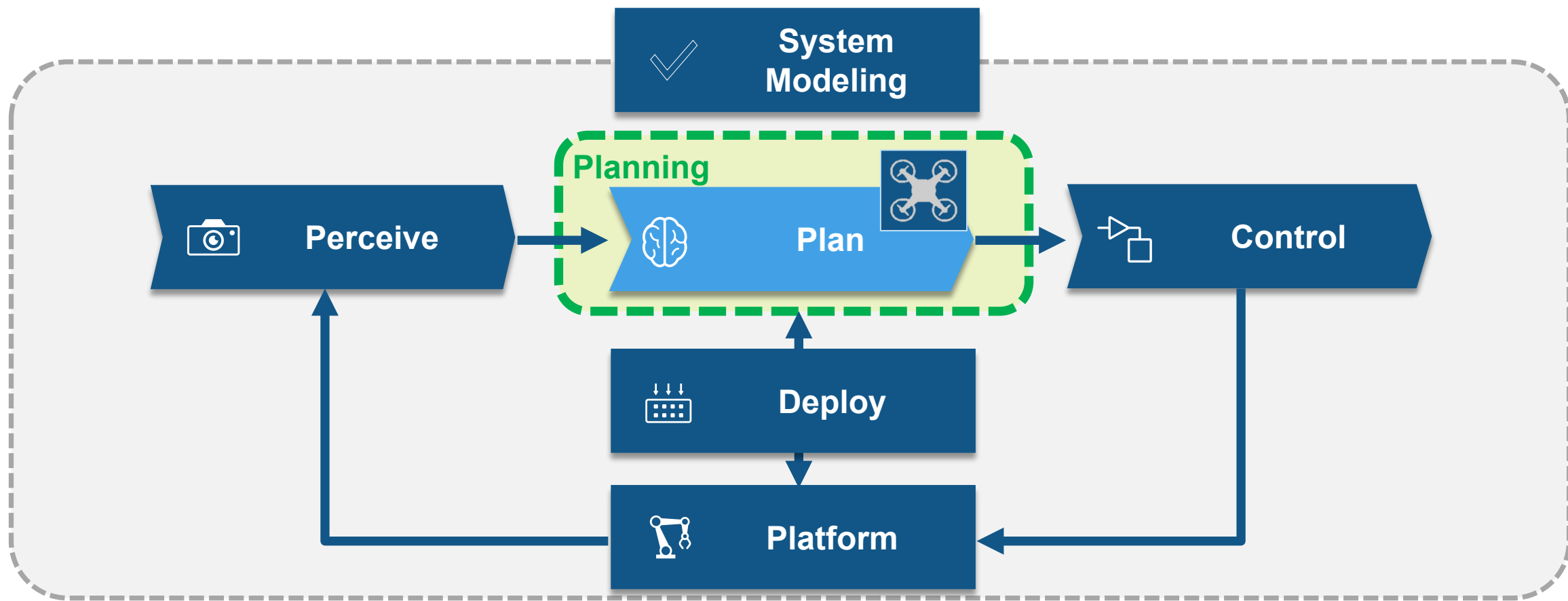
Deep Learning Toolbox  
Image Processing Toolbox  
Computer Vision Toolbox



# 从更广泛的AI社区访问AI模型

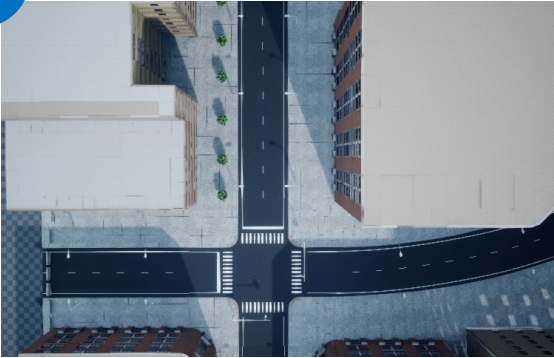


# 自主系统设计工作流程



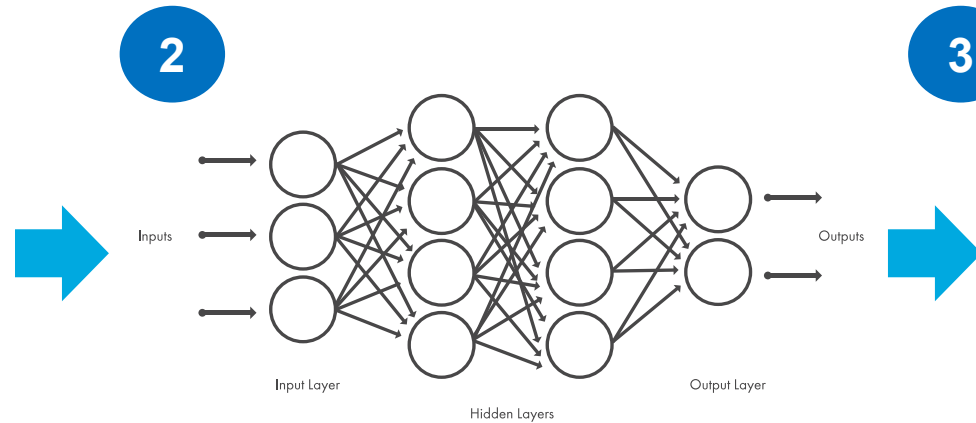
# 预训练AI模型可用于无人机感知

1



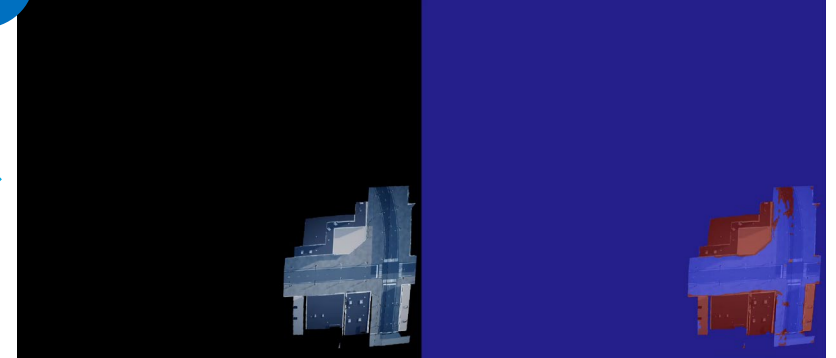
Obtain drone captures images and convert into orthophotos

2



Pass through semantic segmentation network

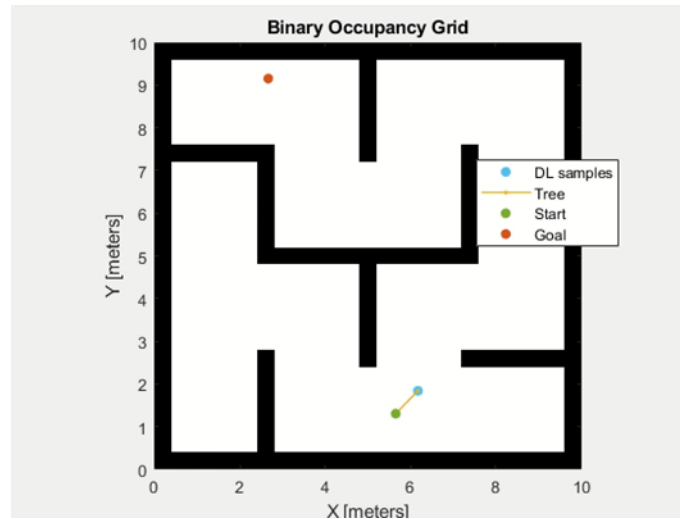
3



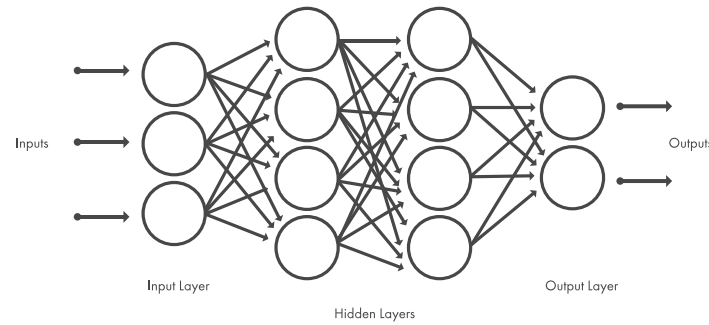
Combine output labels to get final 2D map

Deep Learning Toolbox  
UAV Toolbox  
Computer Vision Toolbox  
Navigation Toolbox

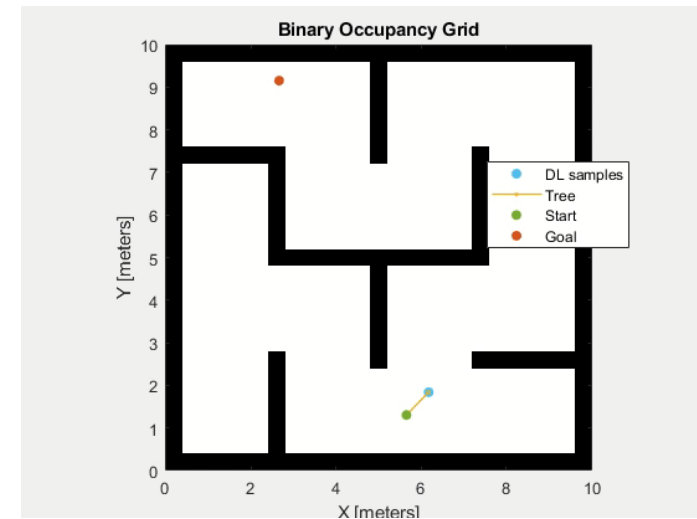
# AI 模型用于无人机运动规划



Define takeoff and landing locations

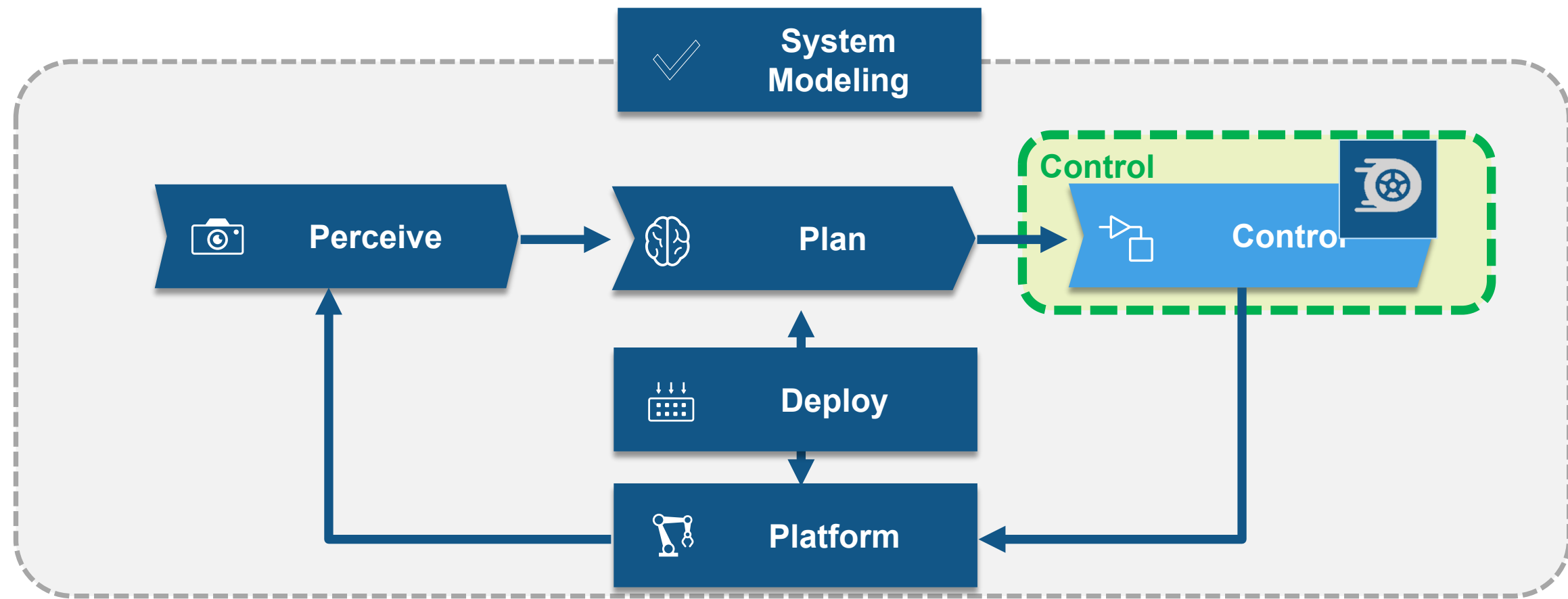


Exploit AI sampler to inform sample-based path planning



Path planned in a feasible time

# 自主系统设计工作流程





# 强化学习用于避障

Define lidar  
sensor  
model

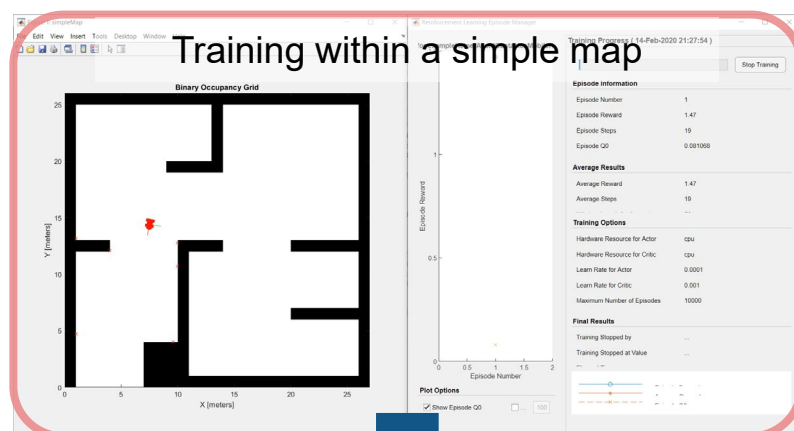
Define RL  
agent

Training in  
simple env.

Scale up to  
realistic env.

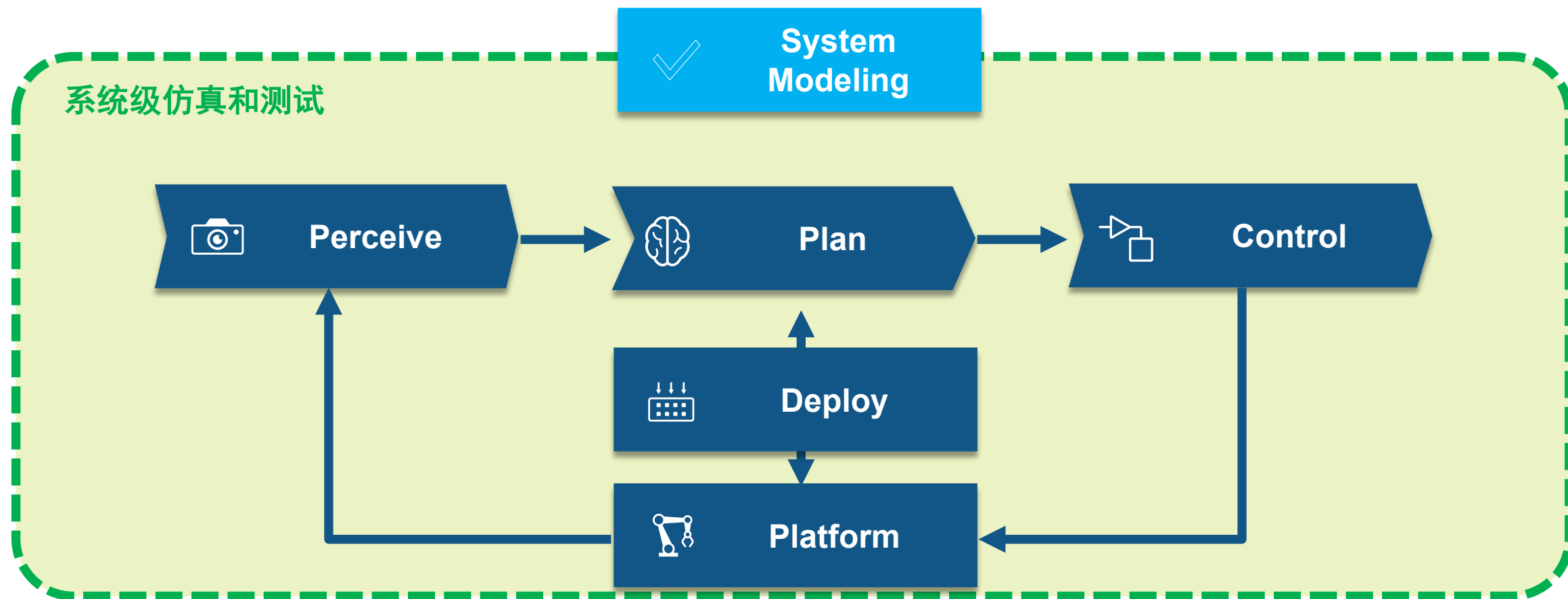
Validation

Visualized in a realistic environment

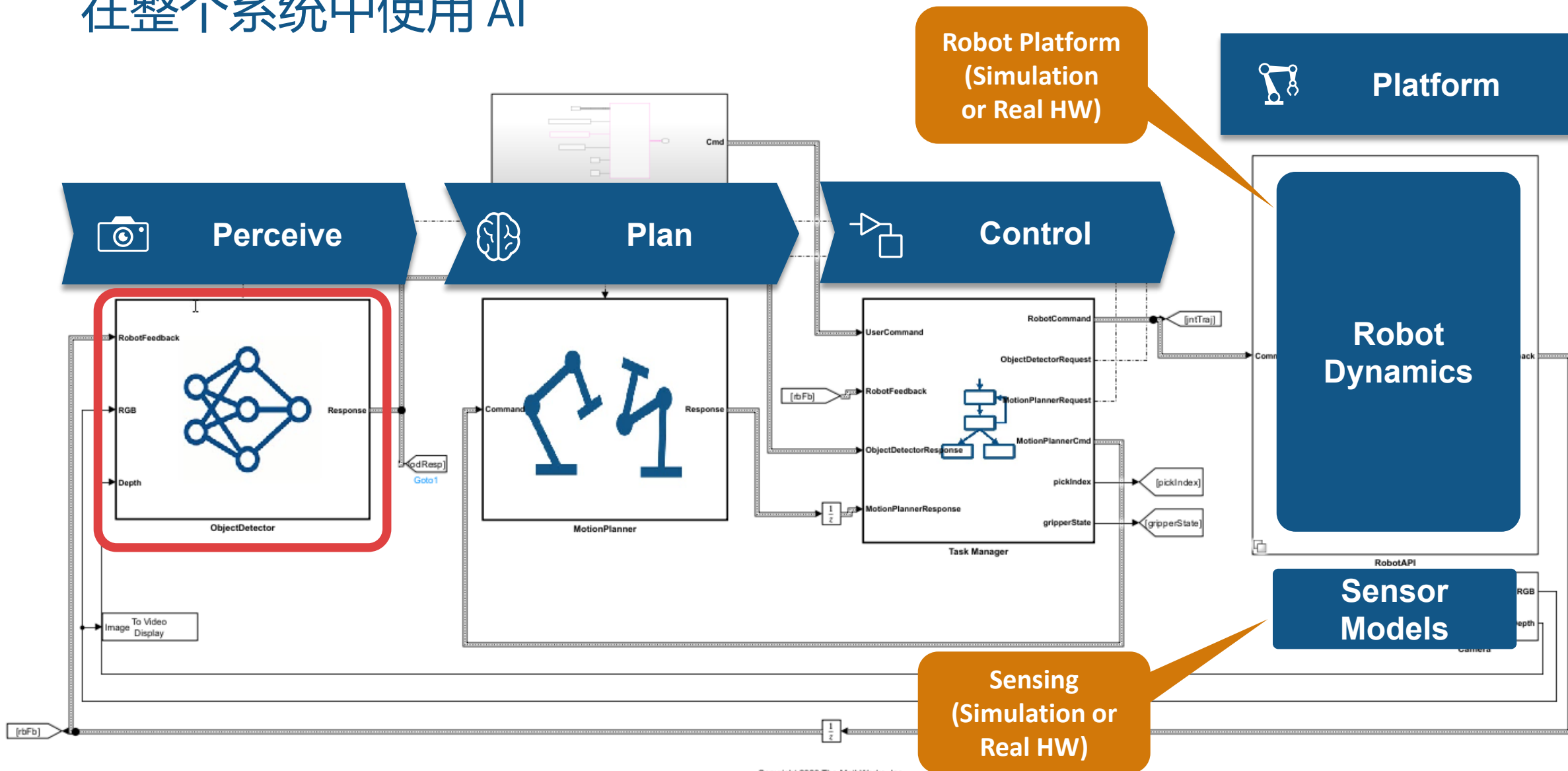


Reinforcement Learning Toolbox, Robotics System Toolbox, Automated Driving Toolbox

# 自主系统设计工作流程



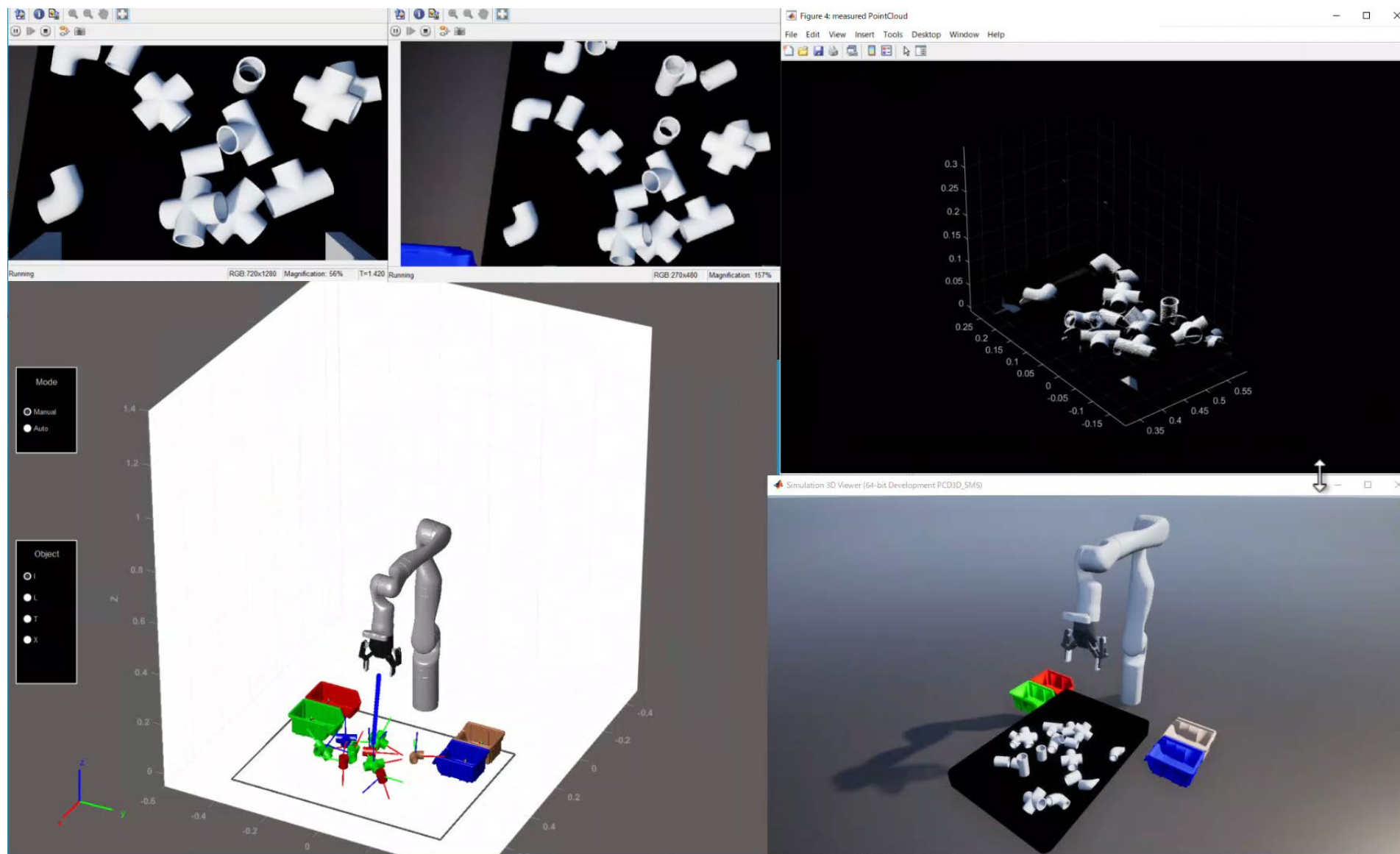
# 在整个系统中使用 AI



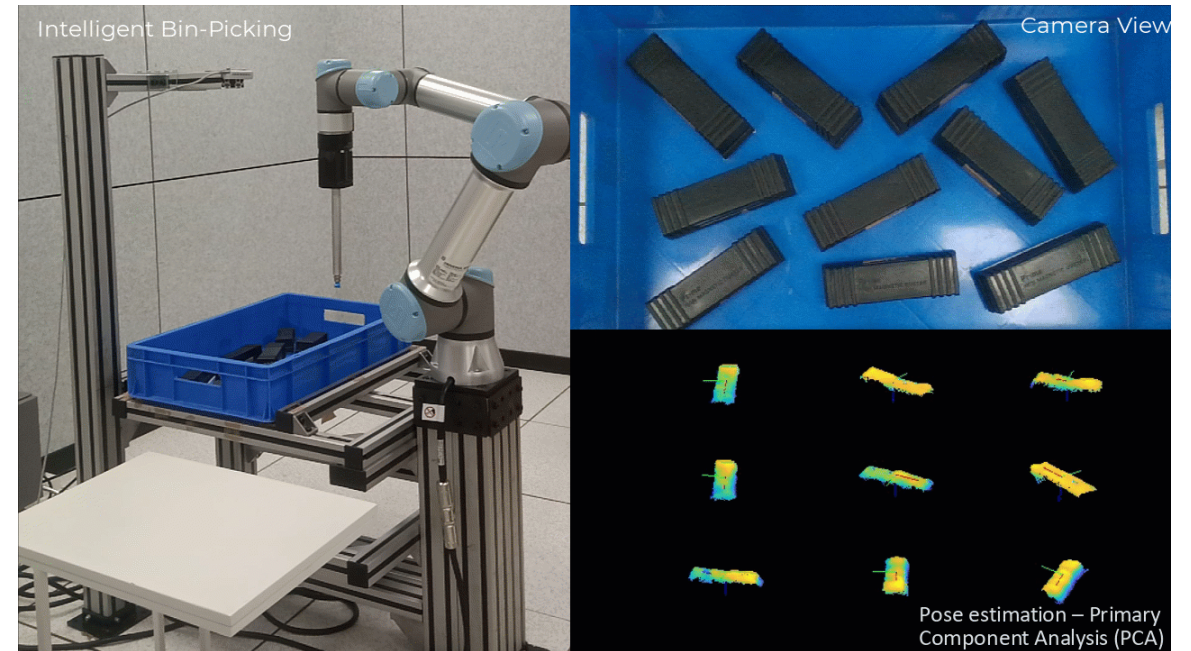
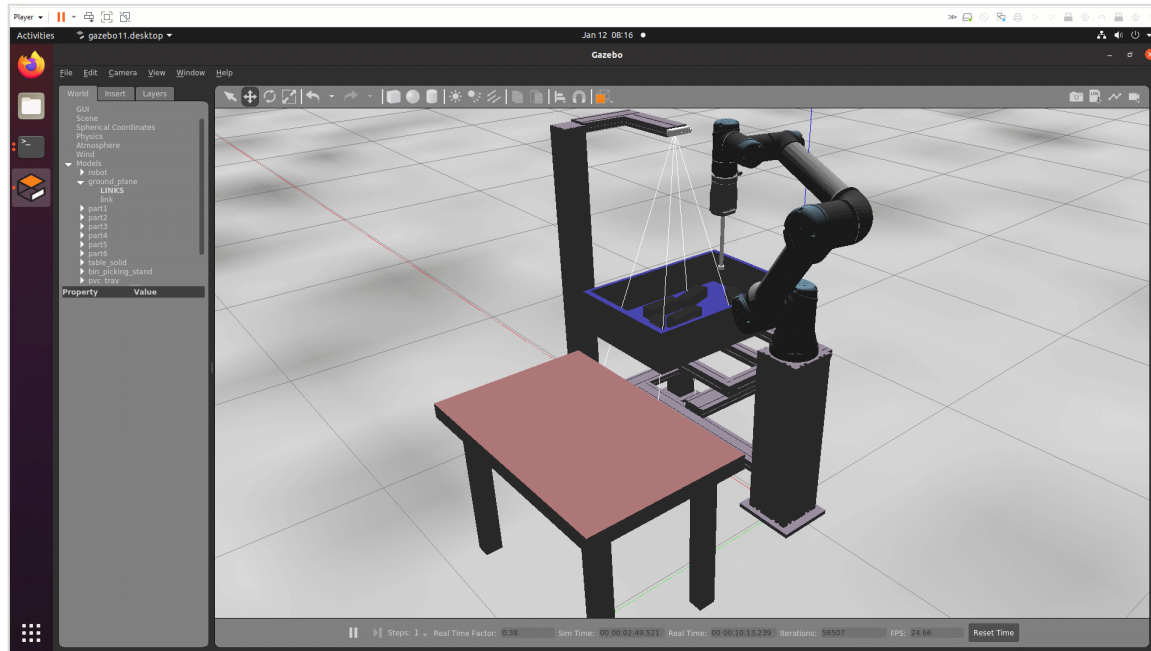


# 端到端仿真中验证 AI 模型

Simulink 3D Animation  
Robotics System Toolbox  
Automated Driving Toolbox

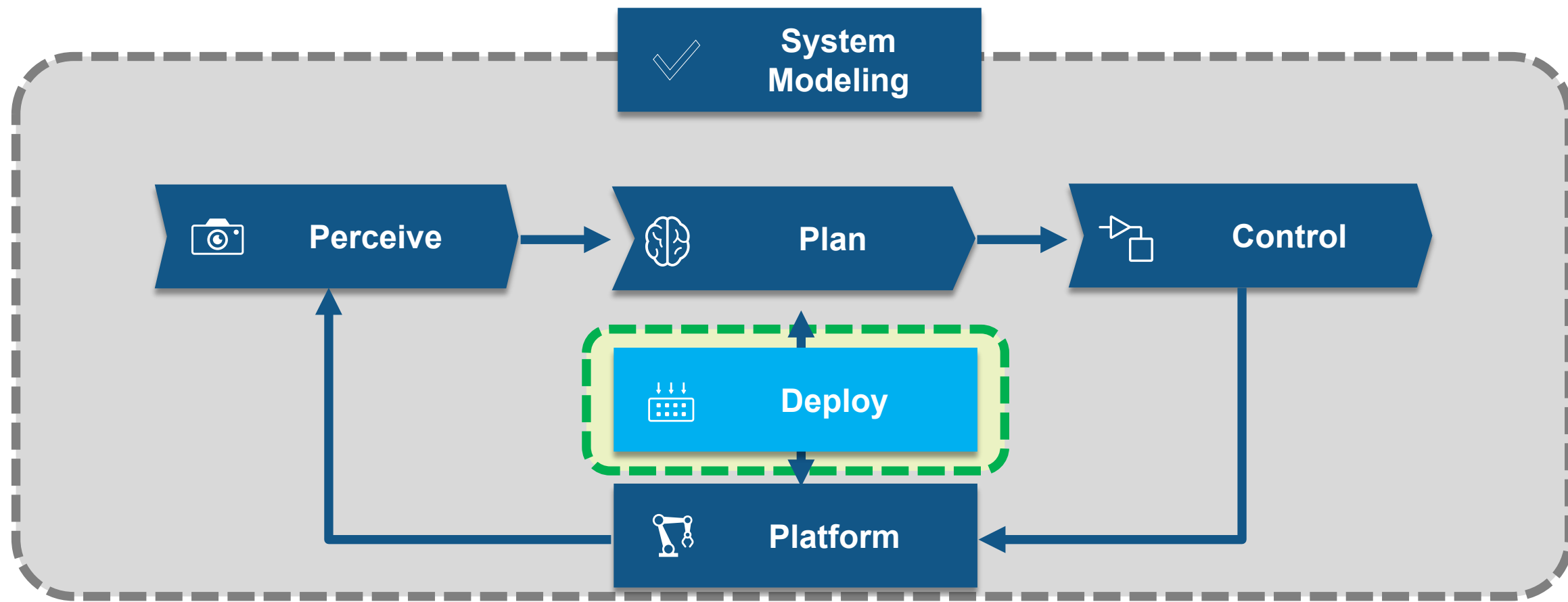


# 易于更换机器人硬件

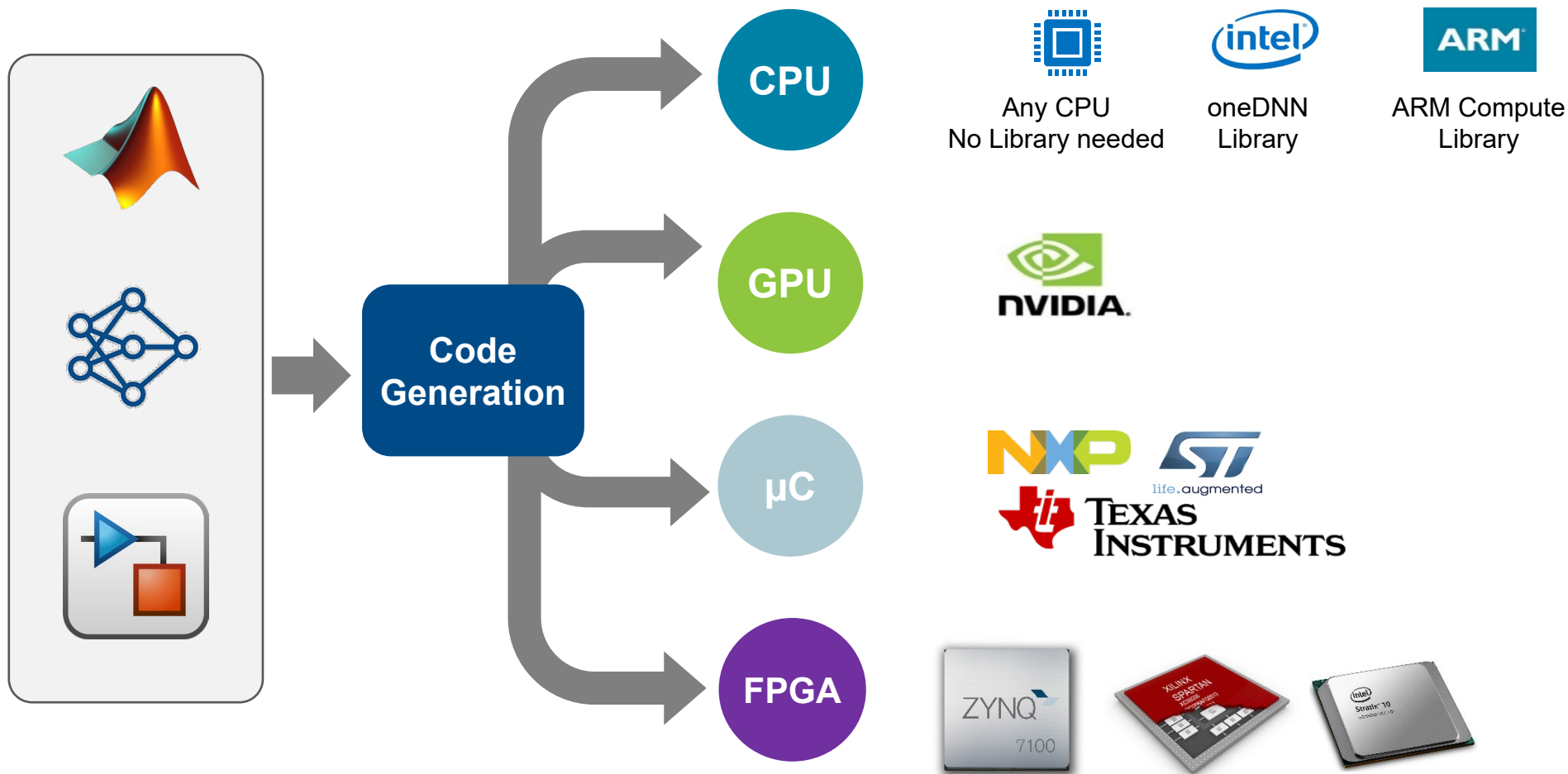


[Robotics System Toolbox Support Package for Universal Robots UR Series Manipulators](#) allows user to connect to and control Universal Robots Cobots over ROS.

# 自主系统设计工作流程

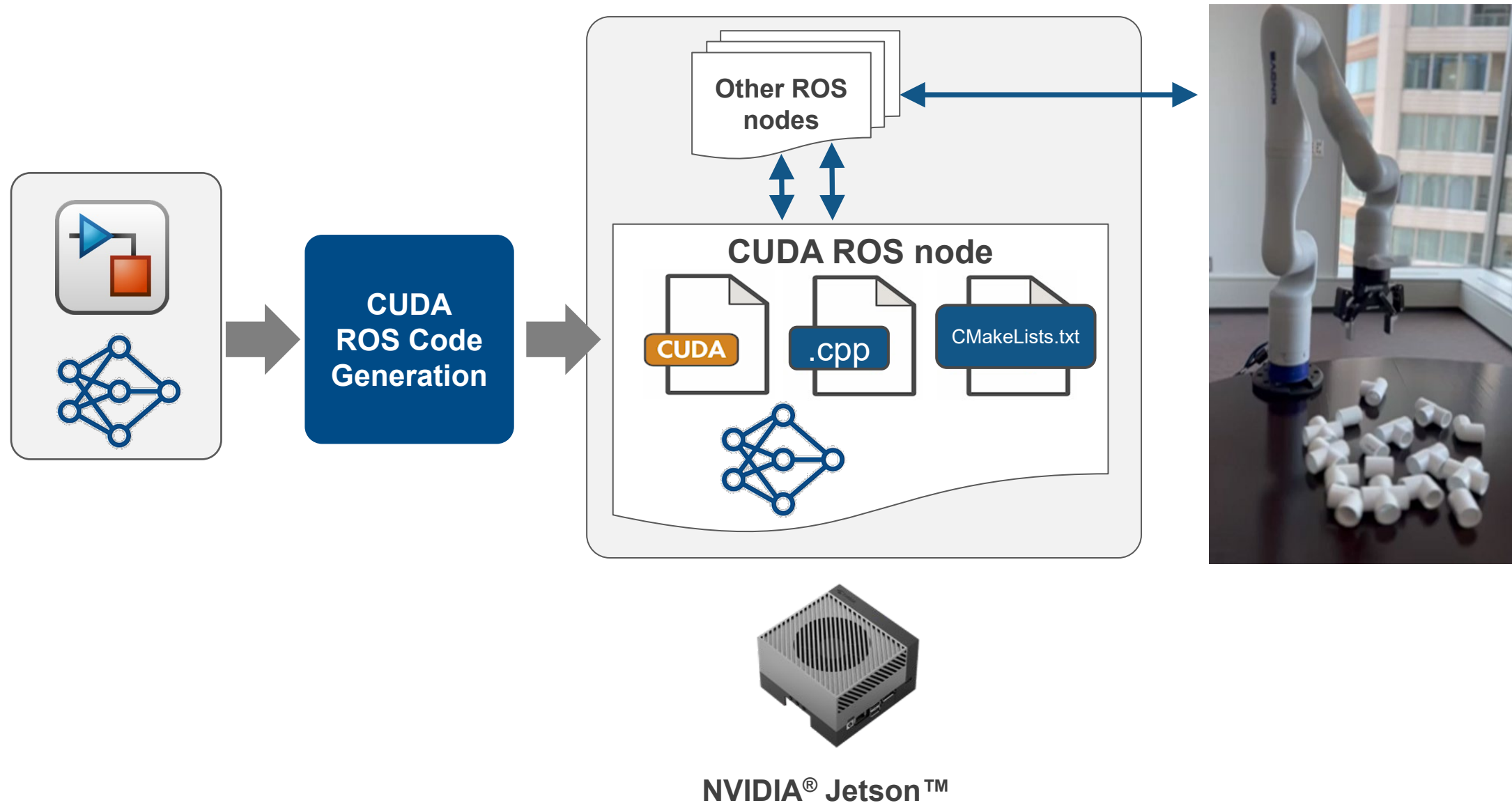


# 零代码错误部署





# 作为 CUDA ROS 节点部署到 Jetson 设备

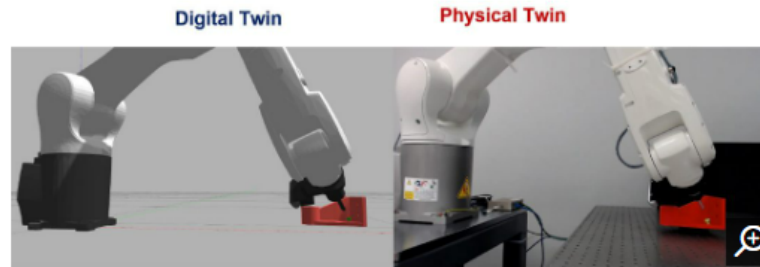


## ASTRI Accelerates Development of Robotic Manipulation System Using MBSE Digital Twin

[Related Link](#)

“The integration of MATLAB, Simulink, and Deep Learning Toolbox gave us the confidence to move forward with the MBSE digital twin project.”

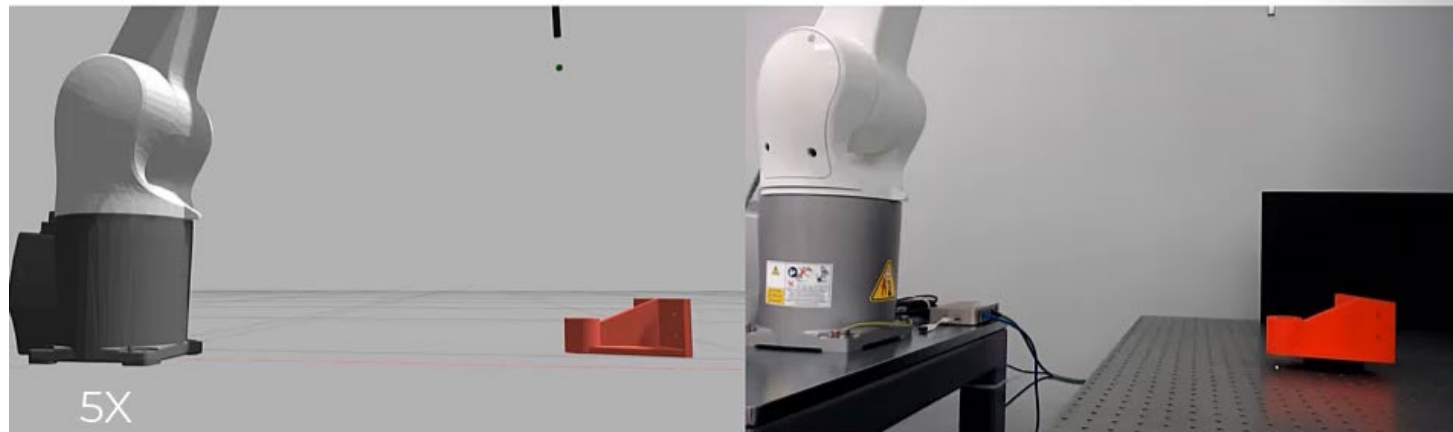
— Dr. T. John Koo, ASTRI



ASTRI created a digital twin to design, build, and validate its robotic welding system.

Digital Twin

Physical Twin



### Challenge

Reduce development time, manual processes, and costs

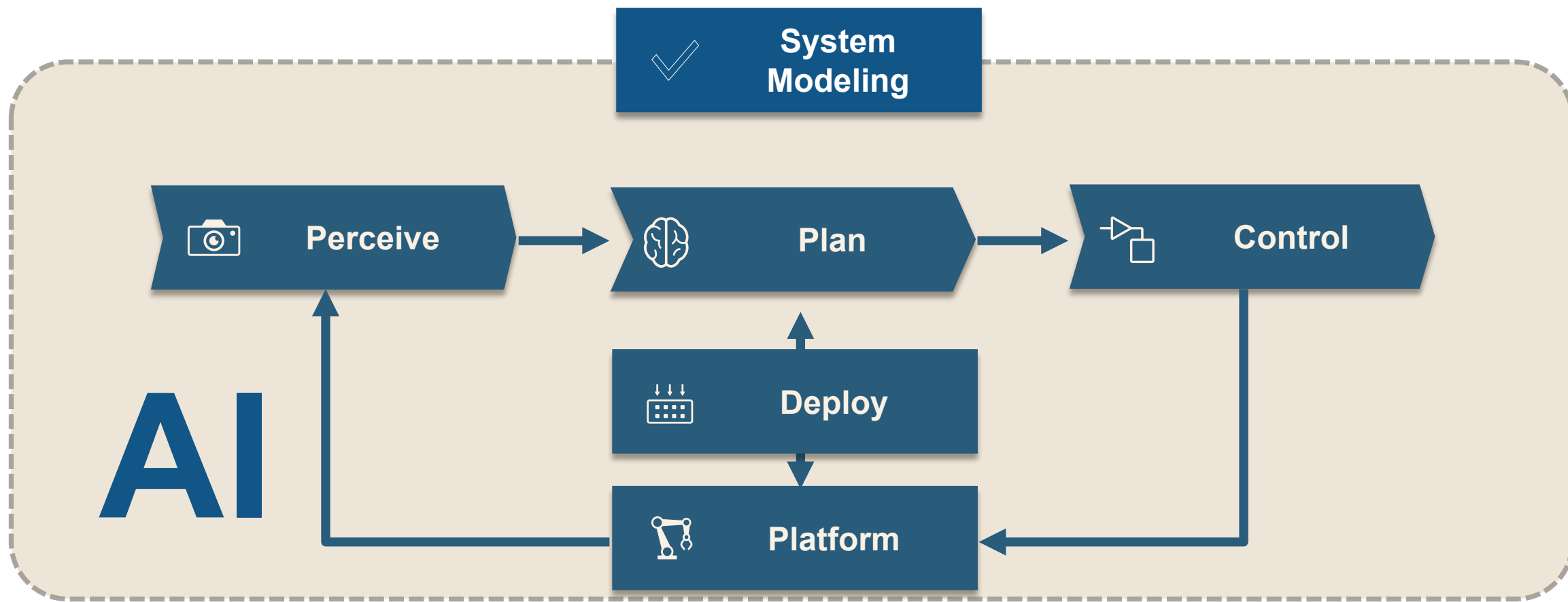
### Solution

Adopt model-based systems engineering and develop a digital twin with MATLAB, Simulink, and Deep Learning Toolbox

### Results

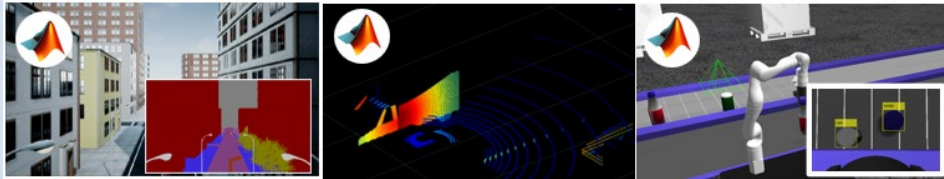
- Integration time reduced by 40%
- Issues resolved in the design stage
- Teams worked collaboratively

# 自主系统设计工作流程



# 将 AI 用于机器人，为什么选择 MATLAB?

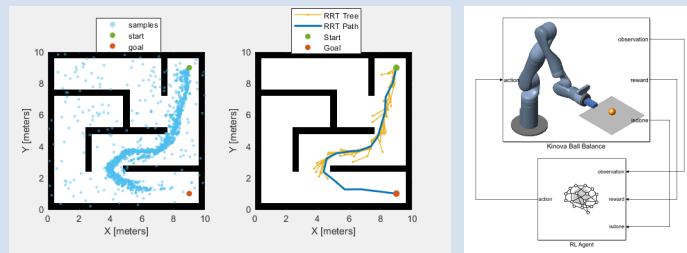
## ❑ Synthetic Training Data Generation



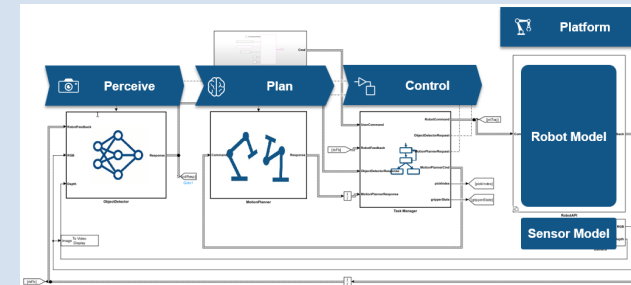
## ❑ Object Identification & Mapping



## ❑ Motion Planning & Controls



## ❑ System Level Testing & Deployment





# 将AI 用于机器人 MATLAB解决方案

 Data Complexity



Simulation

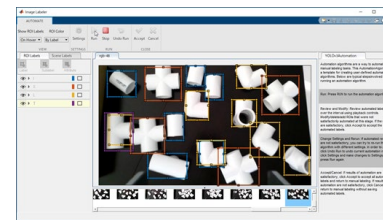
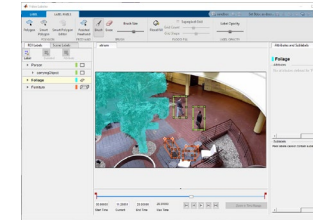


Image Labeler

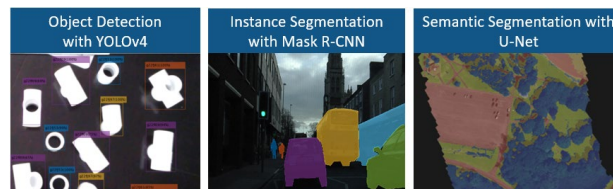


Video Labeler

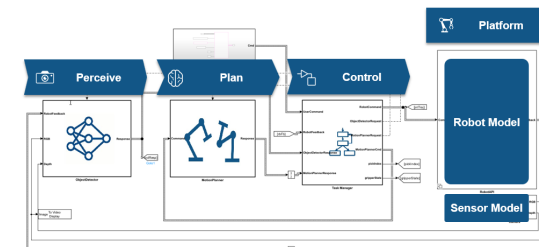
Signal Labeler

Lidar Labeler

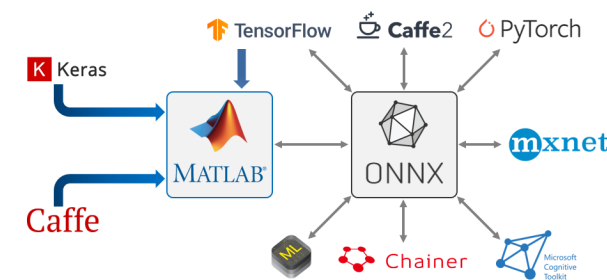
 Model Complexity



Pre-trained models



System-level Simulation, testing, & Deployment



Interoperability with other OS AI models

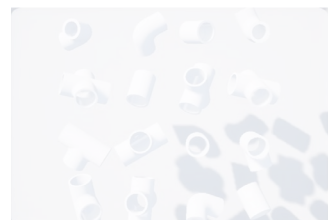
 AI Expertise

Robotics Expertise

vs. AI

# 将AI 用于机器人的挑战:

 Data Complexity



Simulation

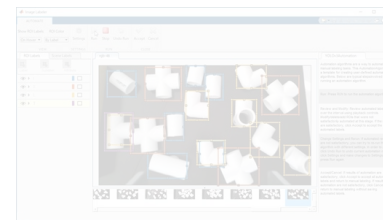
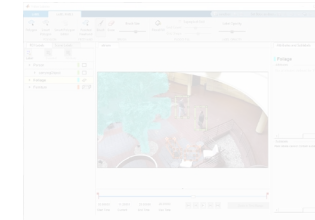


Image Labeler



Video Labeler

Signal Labeler

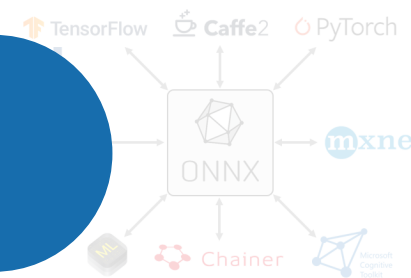
Lidar Labeler

 Model Complexity



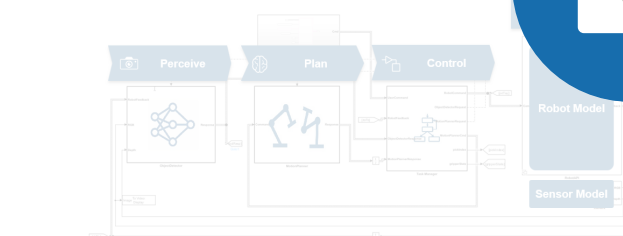
Pre-trained models

 Business



Interoperability with other OS AI models

 AI Expertise



System-level Simulation, testing, & Deployment

Robotics Expertise



AI

# Get Started with AI in MATLAB

## Onramp



### Deep Learning Onramp

Get started quickly using deep learning methods to perform image recognition.

Details and launch



### Machine Learning Onramp

An interactive introduction to practical machine learning methods for classification problems.

Details and launch



### Reinforcement Learning Onramp

An interactive introduction to reinforcement learning methods for control problems.

Details and launch

## Videos

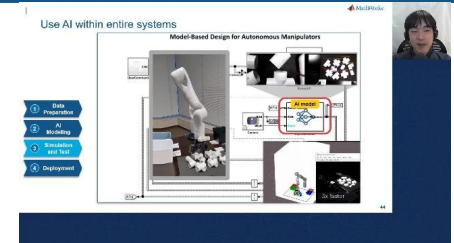


### Deep Learning Tech Talk



### Reinforcement Learning Tech Talk

## Webinars



### AI for robotics

AI for Simulink Users



### AI for Simulink Users

Deploy Deep Neural Networks to NVIDIA GPUs and CPUs from Simulink using GPU Coder



### Deploy Deep Neural Networks

# MATLAB EXPO

Thank you



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