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MATLAB CONFERENCE 2018
Developing Algorithms for Robotics and Autonomous Systems
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Key Takeaway of this Talk

Success in developing robotics and autonomous system requires:

1. Multi-domain simulation
2. Trusted tools which make complex workflows easy
What does success look like?
Platform → Sense → Perceive → Plan & Decide → Control
Can apply this framework to self-driving cars

Planning → Following

Localization → Obstacle avoidance

Global Map → Deep learning

Sense
RADAR
LIDAR
Camera
GPS/IMU

Perceive
Platform

Plan

Control
Steering
Accelerator Braking
Actuator ECUs

Motion Controllers
Today: Design Pick and Place Application
Design Pick and Place Application

Platform → Mechanics → Actuators → Environment

Sense → Perception → Plan & Decide → Control

User_Command → userCommand → visionObjects → Command

Kinect_2 → Pose_Estimator → robotState → Motion_Planner

1/z
Design Pick and Place Application

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

- Mechanics
- Actuators
- Environment

Diagram:
- User_Command
- userCommand
- visionObjects
- Pose_Estimator
- Kinect_2
- robotState
- Motion_Planner
- Command
- z

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Model mechanics using MATLAB and Simulink

```matlab
%% import from URDF
ejaco2n6s300 = importrobot('j2n6s300_standalone.urdf');

%% Solve inverse kinematics
[q_sol,q_info] = ik(ee_link,T_home,weights,q_init);

%% Compute forward dynamics
qddot = forwardDynamics(lbr,q,[],[],fext);
```
Mechanics: One line import from CAD/URDF

```matlab
% Import robot from URDF
smimport('j2n6s300_standalone_stl.urdf');
```
Design Pick and Place Application

Platform → Mechanics → Actuators → Environment

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User_Command → userCommand → visionObjects → Command → robotState → Motion_Planner → \( \frac{1}{z} \)
Model electrical actuators
Actuators: Model other domains
Design Pick and Place Application

Platform → Mechanics → Actuators → Environment

Sense

Perceive

Plan & Decide

Control

User_Command

userCommand

visionObjects

Command

robotState

Motion_Planner

\[ \frac{1}{z} \]
Environment: Connect MATLAB and Simulink with ROS

- MATLAB Code
- Simulink Models
- Built-in algorithms
- Networking
- Code Generation
- ROS Bag import
- ROS node
- Simulation environment
- Robot
Design Pick and Place Application

Platform

Sense

Perceive

Plan & Decide

Control

Demo
Design Pick and Place Application

- Support for Common Sensors
- Image analysis
- Apps
- Image enhancement
- Visualising Point Clouds
Design Pick and Place Application

Platform

Sense

Perceive

Plan & Decide

Control

Platform

Sense

Perceive

Plan & Decide

Control

User_Command
userCommand

userCommand

visionObjects

Kinect_2

Pose_Estimator

Motion_Planner

Command

robotState

Motion_Planner

1/2
Object Classifier and Pose Estimator

Images

Pose Estimator

Labels and Poses

Object 1

Object 2

Object 3

Object 4
MATLAB makes machine learning easy and accessible

Traditional Machine Learning approach

Traditional Feature Extraction  Classification

Machine Learning

Dog ✓
Boy ×
Bicycle ×

Deep Learning approach

Convolutional Neural Network (CNN)

Learned features [95%]

End-to-end learning

Feature learning + Classification

Dog ✓
Boy ×
Bicycle ×
Design Pick and Place Application

- **Platform**
- **Sense**
- **Perceive**
- **Plan & Decide**
- **Control**
Planning: Find a path

Map
Initial Pose
Final Pose

Path Planner

Path

Initial Pose $[x_a \ y_a \ \theta_a]$ Final Pose $[x_b \ y_b \ \theta_b]$
Motion planning with Stateflow
Design Pick and Place Application

Platform

Sense

Perceive

Plan & Decide

Control

Diagram showing the process flow from Platform to Control with intermediate steps involving Sense, Perceive, Plan & Decide.
Design control system in Simulink
Design control system in Simulink
Design control system in Simulink
Design control system in Simulink

Controller

Electrical Actuator
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