MATLAB EXPO 2019

MATLAB® 및 Simulink® 를 이용한 자율주행 시스템 설계 및 시뮬레이션

김종헌
Develop Automated Driving Control Systems with MATLAB and Simulink
Develop Automated Driving Perception Systems with MATLAB and Simulink
Develop Automated Driving Planning Systems with MATLAB and Simulink

Perception

Planning

Control
Develop Automated Driving Systems with MATLAB and Simulink

Simulation Integration

- Perception
- Planning
- Control

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Develop Automated Driving Control Systems with MATLAB and Simulink

Some common control tasks

- Connect to recorded and live CAN data
- Synthesize scenarios and sensor detections
- Model vehicle dynamics
- Design model-predictive controllers
- Design reinforcement learning networks
- Automate regression testing
- Prototype on real-time hardware
- Generate production C/C++ code
- Certify for ISO26262
Synthesize Driving Scenarios to Test Sensor Fusion Algorithms

- Driving Scenario
  - Create scenario
  - Add probabilistic radar and vision sensors
  - Create tracker
  - Visualize coverage area, detections, and tracks

Automated Driving Toolbox™
Sensor Fusion Using Synthetic Radar and Vision Data

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Graphically Author Driving Scenarios

- Driving Scenario Designer
  - Create roads and lane markings
  - Add actors and trajectories
  - Specify actor size and radar cross-section (RCS)
  - Explore pre-built scenarios
  - Import OpenDRIVE roads

Automated Driving Toolbox™
Driving Scenario Designer Example
Synthesize Driving Scenarios from Recorded Data

- Scenario reconstruction
  - Visualize video
  - Import OpenDRIVE roads
  - Import GPS
  - Import object lists

*Automated Driving Toolbox™*

**Scenario Generation from Recorded Vehicle Data Example**

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Integrate Driving Scenarios into Closed Loop Simulations

- Automatic Emergency Braking (AEB) with sensor fusion
  - Specify driving scenario
  - Design AEB logic
  - Integrate sensor fusion
  - Simulate system
  - Generate C/C++ code
  - Test with software in the loop (SIL) simulation

*Automated Driving Toolbox™*
*Stateflow®*
*Embedded Coder®*

**Automatic Emergency Braking (AEB) with Sensor Fusion**

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Design Lateral and Longitudinal Model Predictive Controllers

Longitudinal Control

Adaptive Cruise Control with Sensor Fusion
Automated Driving Toolbox™
Model Predictive Control Toolbox™
Embedded Coder®

Lateral Control

Lane Keeping Assist with Lane Detection
Automated Driving Toolbox™
Model Predictive Control Toolbox™
Embedded Coder®

Longitudinal + Lateral

Lane Following Control with Sensor Fusion and Lane Detection
Automated Driving Toolbox™
Model Predictive Control Toolbox™
Embedded Coder®
Automate simulation tests

- Testing a lane following controller with Simulink Test
  - Specify driving scenario
  - Design AEB logic
  - Integrate sensor fusion
  - Simulate system
  - Generate C/C++ code
  - Test with Software-In-the-Loop (SIL) simulation
Automate simulation tests

- Testing a Lane Following Controller with Simulink Test
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Find out more:
모델기반설계를 이용한 요구사항 기반 검증의 단순화
제어 및 임베드드 시스템 트랙 홍혁기

Requirements link
Simulink Model
Define scenario ID and data initialization
Plot the results
Develop Automated Driving Perception Systems with MATLAB and Simulink

Some common control tasks
- Visualize images, detections, and point clouds
- Label sensor data
- Synthesize scenarios and sensors
- Design fusion and tracking algorithms
- Design vision algorithms
- Design lidar algorithms
- Generate C/C++ code
- Design deep learning networks
- Generate GPU code
Develop Automated Driving Perception Systems with MATLAB and Simulink

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Find out more: 딥러닝과 강화학습

인공지능과 딥러닝 트랙 김종남
Interactively Label Sensor Data

- Get started with the Ground Truth Labeler
  - Label scenes
  - Label regions of interest
  - Label lanes

Automated Driving Toolbox™

Get Started with the Ground Truth Labeler Example
Interactively Label Sensor Data

- Get started with the Ground Truth Labeler
  - Label scenes
  - Label regions of interest
  - Label lanes
  - Label pixels
  - Add label attributes
  - Create sub-labels
  - Group labels

*Automated Driving Toolbox™*

*Get Started with the Ground Truth Labeler Example*
Automate Attributes of Labeled Objects

- Detect vehicles from monocular camera
  - Temporal Interpolation
  - ACF Detector
  - Optical Flow
  - Import automation algorithm into Ground Truth Labeling App

- Run automation algorithm and interactively validate labels

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Automate Attributes of Labeled Objects Example

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Evaluate and Compare Metrics for Fusion and Tracking Algorithms

- Design multi-object trackers
  - GNN + Kalman Filter (KF, EKF, UKF)
  - MHT, IMM, JPDA

- Evaluate tracking metrics

- Evaluate desktop execution time

Sensor Fusion and Tracking Toolbox™
Automated Driving Toolbox™

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Design Detector and Tracker for Lidar Point Cloud Data

- From point cloud to track list
  - Design 3-D bounding box detector
  - Design tracker (target state and measurement models)
  - Generate C/C++ code for detector and tracker

Sensor Fusion and Tracking Toolbox™
Computer Vision Toolbox™

Track Vehicles Using Lidar: From Point Cloud to Track List Example
Design Detector and Tracker for Lidar Point Cloud Data

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Sensor Fusion and Tracking Toolbox™
Computer Vision Toolbox™

Track Vehicles Using Lidar: From Point Cloud to Track List Example
Develop Automated Driving Planning Systems with MATLAB and Simulink

Some common planning tasks
- Visualize street maps
- Connect to HERE HD Live Map
- Connect to recorded and live ROS data
- Design path planners
- Generate C/C++ code
Read Lane and Speed Information from HERE HD Live Map Data

- Use HERE HD Live Map data to verify lane configurations
  - Load camera and GPS data
  - Retrieve speed limit
  - Retrieve lane configurations
  - Visualize composite data

Automated Driving Toolbox™

Use HERE HD Live Map Data to Verify Lane Configurations
Read Lane and Speed Information from HERE HD Live Map Data

- Use HERE HD Live Map data to verify lane configurations
  - Load camera and GPS data
  - Retrieve speed limit
  - Retrieve lane configurations
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Automated Driving Toolbox™

Use HERE HD Live Map Data to Verify Lane Configurations Example

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Automated Parking Valet

- Design automated parking valet path planner
  - Inflate cost map for collision checking
  - Specify goal poses
  - Plan path using Rapidly exploring Random Tree (RRT*)

Automated Driving Toolbox™
Automated Parking Valet Example
MATLAB EXPO 2019
Automated Parking Valet

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Automated Driving Toolbox™
Automated Parking Valet Example
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Automated Parking Valet with Simulink

- Design automated parking valet path planner and controller
  - Design lateral controller (based on vehicle kinematics)
  - Design longitudinal controller (PID)
  - Simulate closed loop with vehicle dynamics

Automated Driving Toolbox™

Automated Parking Valet with Simulink Example

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Develop Automated Driving Systems with MATLAB and Simulink

Simulation Integration

- Perception
- Planning
- Control

Some common integration tasks

- Synthesize scenes and sensors
- Call C/C++ code
- Call Python code
- Co-simulate through FMI/FMU
- Co-simulate through ROS
- Co-simulate with Unreal Engine
- Co-simulate with third party tools
- Automate regression testing
Integrate with ROS

Communicate via ROS to integrate with externally authored ROS components

Robotics System Toolbox™

More Information about ROS-MATLAB Interface:
Simulate Integration of Controls and Perception Systems

Lane Following Control with Sensor Fusion
Model Predictive Control Toolbox™
Automated Driving Toolbox™
Embedded Coder®

Visual Perception Using Monocular Camera
Automated Driving Toolbox™

Lane-Following Control with Monocular Camera Perception
Model Predictive Control Toolbox™
Automated Driving Toolbox™
Vehicle Dynamics Blockset™

R2018b
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Simulate Lane Following Controller with Vision based Perception

- Lane-following control with camera perception
  - MATLAB perception
    - Lane boundary detector
    - Vehicle detector
  - Simulink controller
    - Lane follower
    - Spacing control
  - Add Simulink vehicle model
  - Synthesize ideal camera image from Unreal Engine

Automated Driving Toolbox™
Vehicle Dynamics Blockset™

Lane-Following Control with Monocular Camera Perception Example
MathWorks Can Help You Customize MATLAB and Simulink for Your Automated Driving Application

Voyage develops MPC controller and integrates with ROS
- 2018 MathWorks Automotive Conference

Autoliv labels ground truth lidar data
- Joint presentation with Autoliv
- SAE Paper 2018-01-0043
- 2018 MathWorks Automotive Conference

Ford tests algorithms with synthetic Lidar data from Unreal Engine
- Joint paper with Ford
- SAE Paper 2017-01-0107
Develop Automated Driving Systems with MATLAB and Simulink

Simulation Integration

Perception

Planning

Control

Discuss your application with a MathWorks field engineer to help you structure your evaluation

- Understand your goals
- Recommend tasks
- Answer questions
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