MATLAB EXPO 2018

[Subtrack 2]
Vehicle Dynamics Blockset 소개

김종현 부장
Agenda

- What is Vehicle Dynamics Blockset?
- How can I use it?
Agenda

▪ What is Vehicle Dynamics Blockset?

▪ How can I use it?
Background

- **Context**
  - Automotive OEM’s and Tier 1 suppliers must assess vehicle’s dynamic performance
    - Will the vehicle roll over?
    - What’s the stopping distance of the vehicle?
    - Do the stability controls perform adequately?
  - Answer questions by building prototypes and / or running simulations

- **Challenges**
  - Prototypes are expensive, so must achieve a good design as early as possible
  - Specialized vehicle dynamics simulation software is quite expensive and difficult to use
  - Integrating 3rd party vehicle dynamics software with Simulink controls is cumbersome
Vehicle Dynamics Blockset

New product (R2018a)

- Model and simulate vehicle dynamics in a virtual 3D environment
- Use Vehicle Dynamics Blockset for:
  - **Ride & handling**: characterize vehicle performance under standard driving maneuvers
  - **Chassis controls**: design and test chassis control systems
  - **ADAS / AD**: create virtual 3D test ground for ADAS and automated driving features
Vehicle Dynamics Blockset Features

Library of blocks

Pre-built reference applications

Game engine
Block Library: Powertrain
Block Library: Wheels and Tires

- Longitudinal Wheel - No Brake
- Longitudinal Wheel - Disc Brake
- Longitudinal Wheel - Drum Brake
- Longitudinal Wheel - Mapped Brake

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Block Library: Steering

Kinematic Steering

- AngIn
- AngLft
- AngRght

Mapped Steering

- AngIn
- VehSpd
- AngLft
- AngRght

Dynamic Steering

- TrqIn
- TrqLft
- TrqRght
- VehSpd
Block Library: Suspension
Block Library: Vehicle Body

Vehicle Body Total Road Load

Vehicle Body 1DOF Longitudinal

Vehicle Body 3DOF Longitudinal

Vehicle Body 3DOF Single Track

Vehicle Body 3DOF Dual Track

Vehicle Body 6DOF
Block Library: Vehicle Scenarios
Game Engine Co-Simulation

**Simulink**
- Physics of vehicle
- Initialization of game engine camera

**Unreal Engine**
- Rendering / lighting
- Physics of non-Simulink objects
- Collision detection

Vehicle / camera location

Camera image, ground height, …
Reference Applications

**Vehicle Maneuvers**
Analyze ride and handling on driving maneuvers such as:
- Double-lane change
- Swept sine steering
- Slowly increasing steering

**Scene Interrogation**
Configure the interface to the 3D environment
Agenda

- What is Vehicle Dynamics Blockset?

- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing
  - Assess longitudinal / lateral dynamics
Reference Application: Double Lange Change
Reference Application: Double Lange Change (Maneuver)

Set target velocity and lateral position
Reference Application: Double Lange Change (Driver)

PI controller sets throttle / brake command

Predictive driver model sets steering wheel angle command
Reference Application: Double Lanz Change (Controllers)

- Basic controllers provided for engine, transmission and brakes
- Incorporate your own variants, as needed
Reference Application: Double Lange Change (Plant)

- Use default plant model provided
- Select variants of interest
- Customize subsystems
Reference Application: Double Lange Change (Visualization)

- Scopes, gauges, plotters, logs
- 3D engine interface
Ride and Handling Study: Double Lane Change

At 30 mph

At 50 mph
Agenda

▪ What is Vehicle Dynamics Blockset?

▪ How can I use it?
  – Ride and handling analysis
  – Chassis controls development
  – ADAS / AD testing
  – Hardware-In-the-Loop Testing
  – Perform closed-loop testing
Open loop brake controller simply passes through brake pressure command
Chassis Controls Study: ABS Controller

- Added custom MPC variant to brake controller subsystem
- At each time step, finds optimal brake pressure for target slip ratio
Chassis Controls Study: ABS Controller

Vehicle Speed

- Open-loop brakes
- MPC-based ABS

Tire lock-up

Ideal slip ratio

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Chassis Controls Study: Braking Test

Green: Open-loop brake, white: with ABS
Split Mu Test

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Chassis Controls Study: Split Mu Test
Agenda

- What is Vehicle Dynamics Blockset?

- **How can I use it?**
  - Ride and handling analysis
  - Chassis controls development
  - ADAS / AD testing
  - Hardware-In-the-Loop Testing
  - Test in a virtual 3D environment
ADAS / AD Testing: Virtual 3D Scene

Camera sensor sends video to Simulink

Synthetic video used for testing vision-based algorithms (e.g., lane detection)
Stop Sign Detection and Braking
Customizing Scene with Support Package

- Create your own scenes with Unreal Editor and our Simulink plug-in
- Unreal Editor project files available in our Support Package: “Vehicle Dynamics Blockset interface for Unreal Engine 4”
Editing Support Package Scene to Add Stop Sign
Changing the Lighting to Night Conditions
Perception algorithms are typically developed with different workflows than control algorithms.

Perception re-simulation:
- Images
- Lane detector

Controls simulation:
- "Cuboid" environment & lane sensor
- Physics based vehicle model
- Lane follower
- Detections

Perception engineer

Controls engineer
What is required to combine lane detector and follower components into a system level simulation
Lane detector and follower system

Unreal Engine
- 3D Scene
- Camera sensor

System simulation
- Physics based vehicle model
- Lane detector
- Lane follower

Images
Lane detector and follower system test bench simulates vehicle dynamics with Unreal Engine to synthesize camera images
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  - Hardware-In-the-Loop Testing
HIL Testing

- Do these models run on HIL simulators?
  - Yes!, All blocks in VDBS support code generation except visualization block
  - Tested with Simulink Real-Time on Speedgoat target computer
  - ~270\(\mu\)s turn-around time for 1000\(\mu\)s time step
HIL Testing with UE

- Can you perform HIL testing with Unreal Engine running?
  - Yes!, but UE visualization block doesn’t support code generation.
  - Unreal Engine can run on host PC with GPU.
Summary

- **Vehicle Dynamics Blockset provides:**
  - Open and documented library of component and subsystem models
  - Pre-built vehicle models that you can parameterize and customize
  - Fast-running models that are ready for HIL deployment
  - Interface to Unreal Engine
Frequently Asked Questions: Hardware

▪ What hardware is required to run these models?
  – Simulink only: reference applications run faster than real-time on a modern laptop
  – With 3D engine enabled: Need a good GPU (tested on 1080 nVidia graphics card with 8 GB on-board RAM)

▪ Do we support Mac / Linux?
  – The Simulink models will run on any platform that Simulink supports
  – The UE4 games are compiled for Windows only, so Mac and Linux users must run in Simulink-only mode (for now)