[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: Wheels and Tires

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

MATLAB EXPO 2018
Block Library: Steering

- Kinematic Steering
- Mapped Steering
- Dynamic Steering

MATLAB EXPO 2018
Block Library: Suspension

- Independent Suspension - MacPherson
- Independent Suspension - Double Wishbone
- Independent Suspension - Mapped
- Solid Axle Suspension
- Solid Axle Suspension - Coil Spring
- Solid Axle Suspension - Leaf Spring
- Solid Axle Suspension - Mapped
Block Library: Vehicle Body

- Powertrain
- Wheels and Tires
- Steering
- Suspension
- Vehicle Body
- Vehicle Scenarios

MATLAB EXPO 2011
Block Library: Vehicle Scenarios

- Powertrain
- Wheels and Tires
- Steering
- Suspension
- Vehicle Body

Longitudinal Driver

Lateral Driver

Predictive Driver

Drive Cycle Source
FTP75 (2474 seconds)

Simulation 3D Actor Transform Set

Vehicle Terrain Sensor

Simulation 3D Camera Get

Simulation 3D Actor Transform Get

Simulation 3D Config
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, ...

Diagram of Simulink and Unreal Engine integration.
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 Lange 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

Steering

Transmission

Driveline

Suspension

Vehicle body

Engine

Tire
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

Disc brakes
- 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

- Open-loop brakes
- MPC-based ABS

Vehicle Speed

Tire lock-up

Ideal slip ratio
Chassis Controls Study: Braking Test

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

MATLAB EXPO 2018
Lane detector and follower system test bench simulates vehicle dynamics with Unreal Engine to synthesize camera images
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
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
  - ~270μs turn-around time for 1000μs 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)