Advanced Track and Tire Modeling using SIMPACK User Routines

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SIMPACK User Meeting 2003
• Introduction

• Continuous Track Model

• Implemented SIMPACK User Routines
  – 6 DOF Track Joint
  – Track Sensor
  – Tire Model

• Summary and Perspective
Introduction

Track Models in SIMPACK

“Road Surfaces”
- SIN-Obstacle
- Ramp
- ...

“Tracks”
- Simple Track
- Measured Track
- ...

Associated elements: Track Joint, Track Sensor
Introduction

Tire Models in SIMPACK

Standard Tire Models
- HSRI-Model
- Pacejka Magic Formula
- Pacejka Similarity Method

Non Standard Models
- Delft MF-Tire
- Delft SWIFT-Tire (v8.5)
- RMOD-K (v8.5)

Tire Interfaces
- SIMPACK User Tire
- Standard Tire Interface STI
Introduction

Track and Tire Modeling using User Routines

- Full availability in Symbolic Code (v8.0)
- Flexible definition of tire parameters and output values
Continuous Track Model

- Generated from measured data in a preprocessing step (MATLAB)
- Continuous approximation using splines

\[ x_{Tr}(s), \ y_{Tr}(s), \ z_{Tr}(s), \ \alpha_{Tr}(s) \]
Continuous Track Model

Friction Coefficient

- $\mu$-definition by rectilinear grid
- Grid mapped to track surface or xy-plane of earth coordinate system
Implemented User Routines - Integration of the Track Model into SIMPACK
Implemented User Routines

6 DOF Track Joint

- States provide vehicle position and movement relative to track
- Serves as reference element for tire and track sensor
Implemented User Routines

Track Sensor

- Allows preview relative to Track Joint position
- Preview distance modeled with constant and velocity dependent part
Implemented User Routines - Track Sensor

- SIMULINK example: Controller using Track Sensor data

- SIMULINK track model for advanced controller concepts
Tire Model

Tire Forces:
- HSRI-Model
- Other models can easily be implemented

Tire Kinematics:
- Tire position relative to track
- Contact point, camber angle and slip values
Implemented User Routines - Tire Model

Tire Position Relative to Track

- Track definition: $x_{Tr}(s)$, $y_{Tr}(s)$, $z_{Tr}(s)$, ...
- Current tire position: $x_{Ti}$, $y_{Ti}$, $z_{Ti}$, ...

⇒ Iteration: $s_{Ti} = (x_{Ti}, y_{Ti}, z_{Ti})$
Implemented User Routines - Tire Model

Contact Point Determination

SIMPACK Standard Tire

User Routine Tire
Implemented User Routines - Tire Model

SIMPACK Standard Tire (HSRI)

User Routine Tire

t = 0 s
Implemented User Routines - Tire Model

SIMPACK Standard Tire (HSRI)

User Routine Tire

$t = 2 \text{s}$
Implemented User Routines - Tire Model

SIMPACK Standard Tire

User Routine Tire

$t = 0\ s$

$t = 0\ s$
Implemented User Routines - Tire Model

SIMPACK Standard Tire

User Routine Tire

$t = 7 \text{ s}$
Implemented User Routines - Tire Model

- Camber velocity induces slip angles
- Camber velocity induces slip angles
- Resulting lateral forces may excite system when using simple algorithm
Summary

- Track and tire model now available for Symbolic Code Export
- Proved Track Joint concept is retained
- Improved contact point determination

Perspective

- Integration of superior tire models
- Enhanced pre- and postprocessing
- Porting to SIMPACK v8.5