Vehicle Dynamics and Control

Fall 2010

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References

1. “Vehicle Dynamics and Control”, Rajesh Rajamani, Springer, 2006.
2. “Fundamentals of Vehicle Dynamics”, Thomas D. Gillespie, SAE, 1992.
3. “Theory of Ground Vehicles”, 3rd Ed., J.Y. Wong, Wiley Interscience, 2001.
4. “Vehicle Handling Dynamics”, 1st Ed., Masato Abe, Elsevier, 2009.
5. “Tire and Vehicle Dynamics”, Hans B. Pacejka, SAE, 2002.

Major Course Contents

Part 1: Lateral Vehicle Dynamics

- 1.1 Vehicle Dynamic Model
- 1.2 Planar Model
- 1.3 Bicycle Model
  - Bank angle/crosswind
- 1.4 Tire Models
- 1.5 Understeer/oversteer
- 1.6 Dynamic model interms of error wrt road
- 1.7 lane keeping model
- 1.8 Phase plane analysis
- 1.9 Lateral stability Control

Part 2: Longitudinal Vehicle Dynamics

Part 3: Vehicle Control Systems

Part 4: Suspensions

Part 5: Three-dimensional rigid body model of a vehicle

Major Course Contents

Part 2: Longitudinal Vehicle Dynamics

- 2.1 Longitudinal Dynamic Model
- 2.2 Engine model
- 2.3 Transmission
- 2.4 Tire models
- 2.5 Brake

Part 3: Vehicle Control Systems

- 3.1 Driver Model
  - driver-in-the-loop systems
- 3.2 Lateral Stability Control (sec. 1.9)
- 3.3 Lane Keeping Systems
- 3.4 Adaptive Cruise Control
- 3.5. Tire-road friction estimation
- 3.6 Tire force estimation
- 3.7 Vehicle state estimation:
  - - side slip angle, vehicle speed
- (3.5 Autonomous Driving Systems)
- (3.8 Fault detection and Failsafe Systems)

Major Course Contents (contd.)

(tentative, Optional)

Part 4: Suspensions

- 3.1 Fundamental properties of suspensions
- 3.2 Invariant properties
- 3.3 Ride quality
- 3.4 Active/semi-active suspensions

Part 5: Three-dimensional rigid body model of a vehicle

- 5.1 Newton/Euler formulation –review
- 5.2 14 DOF vehicle model (6+4+4)

Understand the underlying physics and being able to construct models to analyze and predict vehicle behavior

Control system design for safety and maneuverability

End of Introduction

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Review (1/3) Fall 2010

Part 1: Lateral Vehicle Dynamics

1. Rigid body dynamics, Three dimensional dynamics
1.1 Vehicle Dynamic Model – overview : 6 dof body dynmics
1.2 3 DOF Planar Model
1.3 2 DOF Bicycle Model
Linear tire model, tire slip angle, cornering stiffness
1.4 2 dof bicycle model based steady state turning analysis
- understeer/oversteer
- understeer coefficient, characteristic speed, critical speed
1.5 Bank angle/crosswind model
1.6 Dynamic model in terms of error wrt road
- Lane keeping model: feedback and feedfoward steering model
1.7 Introduction to Tire dynamics, Tire Models
-longitudinal/lateral tire force model, self aligning moment
-Pacejka Model, Dugoff Model, The brush model
1.8 Lateral Stability
-nonlinear tire model
-Phase plan analysis
1.9 Lateral stability control
- direct yaw moment control

Review (2/3)

Part 2: Longitudinal Vehicle Dynamics

- **2.1 Longitudinal Dynamic Model**
  - **- vehicle body dynamics, rolling resistance, aerodynamic force**
- **2.2 Engine model: 2state engine dynamic model, engine map**
- **2.3 Torque converter model, Transmission and wheel dynamics**
- **2.4 Tire models**
- **2.5 Brake model**

Review (3/3)

Part 3: Vehicle Control Systems

3.1 Adaptive Cruise Control
- **set speed control**
- **clearance control**
- **engine/brake switching logic**
- **string stability : definition, sliding control for string stability**

3.2 State estimation for vehicle control
- **vehicle longitudinal velocity estimation**
- **vehicle lateral velocity estimation: body side slip angle estimation using bicycle model**
  : linear model based/nonlinear tire model based approaches
- **estimation of acceleration bias**
- **Review of Kalman filter/extended Kalman filter**

3.3 Tire-road friction estimation
- **definition**
- **longitudinal model based**
- **lateral model based methods**

3.4 Driver Model
driver-in-the-loop systems
3.5 Tire force estimation
(3.6 Autonomous Driving Systems)
(3.7 Fault detection and Failsafe Systems)