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CONNECTED AUTOMATED VEHICLES AND ITS, VEHICLE DYNAMICS AND CONTROL

Vehicle's Lateral Motion Control Using Dynamic Mode Decomposition Model Predictive Control for Unknown Model

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Abstract
In this paper, we present a data-driven modeling method for lateral motion control of unknown vehicle models. Vehicle's motion can be modeled linearly but this model has complex and nonlinear characteristic. Therefore, it is necessary to know the exact information of the car chassis and requires a knowledge and understanding of dynamics. To solve these drawbacks, we linearly represent full vehicle's lateral dynamics which include nonlinear behavior using dynamic mode decomposition (DMD), one of the data driven modeling methods. To determine the validity of the model obtained using the DMD method, we conducted a simulation of the comparison of the output states between the existing model and the model obtained through DMD modeling, using the scenario of a dynamic maneuver called a double line change during lateral motion of a vehicle. After determination of validation is completed, we designed a lane keeping system by applying a model predictive control to specifically evaluate the model of the proposed method. Performance was derived by comparing the error caused by the vehicle driving on the course with the controller of the simulation. The performance of the proposed approach has been evaluated through simulations and is useful when the model is inaccurate.

Keywords Data-driven modeling · Dynamic mode decomposition · Model predictive control · Lane-keeping control

List of symbols

δ	Steering angle
$\dot{\psi}$	Vehicle's yaw rate
ψ	Vehicle's yaw in a global axis
$\{X^g Y^g Z^g\}$	Global coordinate frame
$\{x^l y^l z^l\}$	Local coordinate frame
C_α	Cornering stiffness of tires
e_ψ	Yaw angle error with respect to road
e_y	Lateral position error with respect to road
F	Lateral tire force
I_z	Vehicle's Yaw rate of moment
L	Distance from c.g. to the look-ahead point
l	Distance of c.g. tire
m	Vehicle's total mass
V	Total velocity at c.g. of vehicle
θ_{sw}	Steering wheel angle

Subscripts

f, r, d : Front, rear, desire

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1 Introduction

In recent years, numerous research has been conducted on vehicle control for advanced driver assistance system (ADAS) in the field of autonomous vehicle control. Among autonomous vehicle control (Li et al., 2020; Lee et al., 2012, 2019; Wang et al., 2019) lateral control is receiving a lot of attention in various research fields such as lane keeping system, lane change system and automatic parking. A model of a system representing the operation of a vehicle is essential in designing a lateral controller of an autonomous vehicle. In general, kinematic models that can effectively represent the motion of vehicles when driving at low speeds are widely used in vehicle lateral controller design (Kang et al., 2018; Kong et al., 2015). On the other hand, when the