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MODELING AND ANALYZING INDIVIDUAL DRIVER'S STEERING BEHAVIOR BASED ON ROLLING LOCAL-PATH PLANNING DECISION

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ABSTRACT–A good understanding driver behavior is significant in the development of chassis control system and autonomous vehicles. To better simulate human drivers, the driver model with the local path rolling planning decision is developed based on model predictive control algorithm. Firstly, three local path planning methods of straight-line driving, circular-arc driving and B-spline curve driving are designed to describe the different steering styles. Secondly, the linear time-varying (LTV) MPC controller is established to follow the local planned path. Finally, the two typical simulations are carried out and compared with the single-point preview driver model and the optimal preview driver model. And, the results indicate that the proposed driver model is suitable for simulating diversity of the human driver's driving characteristics.

KEY WORDS : Steering characteristics, Model predictive control, Driving style, Local planning path

NOMENCLATURE

a	: distance from mass center to front wheel, *m*
b	: distance from mass center to rear wheel, *m*
m	: vehicle mass, *kg*
Iz	: yaw moment of inertia, kgm^2
k_1, k_2	: lateral cornering stiffness of front wheel and rear wheel, *N/rad*
u	: longitudinal velocity, *km/h*
v	: lateral velocity, *km/h*
r	: yaw rate of predictive model, *deg/s*
α_1, α_2	: sideslip angel of front and rear wheel, *deg*
δ	: front road wheel steering angle, *deg*
ψ	: heading angle, deg
t	: current time, *s*
T_p	: driver's preview time, *s*
N_p	: prediction horizon
N_c	: control horizon
η_{ref}	: local planning path
Γ	: correction of predictive model
U_{max}	: input maximum of front wheel angel, *deg*
ΔU_{max}	: input maximum increment of front wheel angle, *deg*
r_{max}	: maximum of yaw rate, *deg/s*
Q	: weight coefficient matrix of path following ability
R	: weight coefficient matrix of control increment

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1. INTRODUCTION

With the development of modern technology, vehicle is one of the indispensable traffic tools for people. However, vehicles also cause the serious traffic safety problems. Most of the accidents are caused by human driver's wrong operation (Zhu and He, 2017; Sun and Chen, 2010). Better understanding human driver's characteristics can more realistically simulate some situations in actual driving, which is very essential for the chassis control system and autonomous vehicle designs.

For about half a century, the topic of understanding the driver behavior has attracted scholars at home and abroad from many different fields. They propose various driver model based on different assumptions and theories such as two-point preview (Guo *et al*., 2021), multi-point preview (Sharp, 2005), optimal curvature preview, optimal preview (Yang *et al*., 2017; MacAdam, 1981) and other driver models (Aksjonov *et al*., 2018; Guan *et al*., 2013). Up to now, the common feature of these driver models is always aimed at minimizing the errors between the actual and desired trajectory based on the "preview-following" theory brought forward by scholar of Guo (Guo and Fancher, 1983).

Based on "preview follow" theory, Zhang *et al*. (2014) and Ding *et al*. (2007) discussed the analytical method to calculate the driver parameters and analyzed the effect of parameters on path following ability. Naranjo *et al*. (2008) and Feng *et al*. (2021) designed driver model based on fuzzy logical control to simulate the human driver's steering behaviors. Buckholtz (2002), Wang *et al*. (2020) and Ali *et al*. (2022) used sliding model control to simulate driver