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Analysis of Highway Merging Driving Behavior by Parameter Estimation of Discrete Choice based Driver Model using Data from Networked Multi-Paricipant Driving Simulator

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Background and Objectives

Merging on expressways is a cognitively demanding task, and understanding human merging behavior is essential for designing and evaluating merging assistance systems. However, drivers must constantly assess spatial and temporal constraints and anticipate interactions with mainline vehicles, making it difficult to derive time-series behavior models directly from raw data. As a preliminary step, this study visualizes human decision-making during merging using a multinomial logit (MNL) model to identify key factors—such as relative speed, time-to-collision, and lateral clearance—that shape driver decisions. We also examine how individual characteristics relate to behavioral differences. The findings support methodologies for modeling human behavior from interactive time-series data and provide a basis for developing agent models for closed-loop simulation.

Methodology

We conducted a highway merging experiment using a networked multi-driver driving simulator (NMDDS), enabling multiple participants to share the same virtual traffic environment. Merging-scenario data with interactions between merging and mainline vehicles were collected from ten participants. Each participant's driving characteristics were first identified through an IDM-based car-following task, and participants were clustered to select representative aggressive, cautious, and average drivers. For each representative driver, a nonlinear multinomial logit (MNL) model (Fig. 1) was constructed using variables such as relative speed, TTC, lateral clearance, PET, and DRAC. Sensitivity coefficients were analyzed to reveal links between individual characteristics and behavioral tendencies.

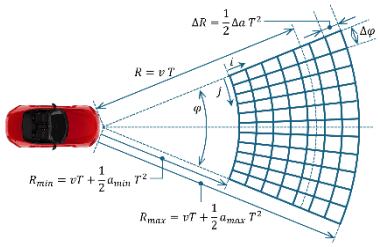

Fig. 1 Arrangement of the Grid for MNL

Results/Conclusions

Based on the clustering results derived from the identified IDM parameters, HDV8, HDV5, and HDV9 were selected as representative drivers with aggressive, cautious, and average driving characteristics, respectively (Fig.2). For these participants, MNL models with sufficient goodness-of-fit and stability were successfully constructed (Table 1). The estimated sensitivity coefficients clearly reflected individual driving tendencies—for example, the aggressive driver showed strong sensitivity to temporal risk factors such as TTC. These findings indicate that the models capture characteristic behavioral differences among drivers. Future work will focus on incorporating interaction effects more effectively and extending the models toward agent-based representations.

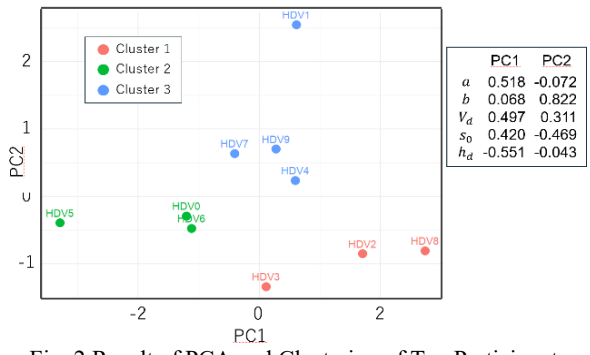

Fig. 2 Result of PCA and Clustering of Ten Participants

Table 1 Estimated Parameters and Model Fit Statistics

	HDV8		HDV5		HDV9	
Estimated Parameters						
LongProg:	Value	p-Value	Value	p-Value	Value	p-Value
RVEL_f			0.448	0	0.908	0
RVEL_r						
TTC_f	5.30	5.24E-11	3.82	0		
TTC_r						
LatProg:	Value	p-Value	Value	p-Value	Value	p-Value
BOUND	-0.847	0			-0.455	0
LAT			-0.0908	0	-0.263	0
PET						
Safety:	Value	p-Value	Value	p-Value	Value	p-Value
DRAC_f						
DRAC_r						
Model Fit Statistics						
Null log likelihood	-11532.80		-10212.29		-10229.66	
Final log likelihood	-10984.52		-10044.05		-9957.79	
LR test	1096.56 (df=2, p<0.001)		336.47 (df=3, p<0.001)		543.75 (df=3, p<0.001)	
AIC	21973.04		20094.09		19921.57	
Condition Number	111.18		23.27		3.41	