講演番号	227

Estimation of Driving Style Based on Eye Tracking During Autonomous Driving

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KEY WORDS: **Human Engineering, Driving act/driver behavior, Individuals difference/variation,** Eye tracking [C2]

Personalizing the controls of a driving assistance system is expected to encourage drivers to use the system appropriately. In existing research, obtaining driving data from the individual in question is necessary for personal adaptation. It has been shown that, even in autonomous driving environments, individual differences in gaze dispersion arise based on perceived importance. Although gaze patterns differ between manual and autonomous driving, the basic tendencies of gaze strategies remain consistent across drivers. Therefore, it was hypothesized that a driver's driving style might also be reflected in their gaze patterns during autonomous driving.

This study attempted to estimate drivers' braking style based on eye tracking data collected during autonomous driving using a driving simulator. If driving style can be solely from gaze information during autonomous driving, real-time, personalized control adaptation may be achieved even at high levels of automation, without the need to collect data related to driving control.

In this study, the relationship between gaze measurement data during autonomous driving and driving data during manual driving was analyzed and modeled. The driving data for both conditions were collected through driving experiments using a driving simulator. In the experiment, data from 15 participants for both manual and autonomous driving were collected during situations where the vehicle slowed down and stopped in response to approaching the preceding vehicle. Under manual driving conditions, the pedal and steering wheel inputs were recorded. In addition, the positional coordinates and speeds of the test vehicle and the preceding vehicle were recorded. Furthermore, under both conditions, participants' gaze positions were measured using an eye-tracking device (EMR-10, NAC Image Technology Inc.).

Figure 1 shows that drivers with two different driving styles were identified based on their driving behavior during manual driving, specifically regarding braking distance and the stopping distance. It was found that their tendencies toward focusing or distributing their gaze during autonomous driving differed according to these styles. Table 1 shows the top five features with the large absolute effect size for each phase.

Drivers with long braking distances and short stopping distances tend to perceive and assess the situation by checking various points of interest. Particularly during deceleration, there is a strong tendency to look at the vehicle ahead and the mirrors. This suggests that drivers prefer to come to a gentle stop by recognizing their proximity to the vehicle ahead at an early stage and beginning to decelerate promptly. In contrast, drivers with short braking distances and long stopping distances tend to selectively perceive and judge information by regularly directing their gaze towards the road ahead or the instrument panel. In particular, during deceleration, there is a strong tendency to look at the instrument panel. This suggests that drivers prioritize the timing of speed adjustment and favor maintaining a sufficient distance.

By using gaze features that show large differences across driving styles to construct a driving style prediction model, the model was able to predict driving styles with 60% accuracy. Although further improvements in accuracy are desired, the realization of such estimations is expected to expand the feasibility of personalization in driving assistance systems.

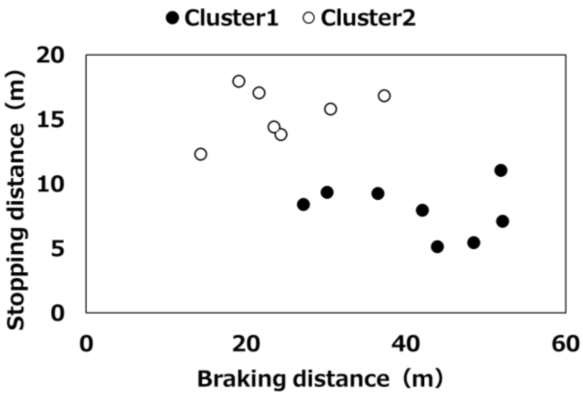

Fig.1 Scatter plot of average braking distances and stopping distances acquired at manual driving

Table 1 Five features with large absolute effect size for each phase

Rank	Driving		Braking		Stopping	
	Feature	Cohen's d	Feature	Cohen's d	Feature	Cohen's d
1	Switching rate	0.75	Dwell proportion of forward	-0.66	Dwell entropy	0.97
2	Dwell proportion of right mirror	0.73	Dwell proportion of instrument panel	-0.59	Dwell proportion of forward	-0.75
3	Dwell entropy	0.66	Dwell proportion of preceding vehicle	0.53	Dwell proportion of preceding vehicle	0.67
4	Dwell proportion of forward	-0.56	Dwell proportion of left mirror	0.43	Switching rate	0.57
5	Markov based perplexity	0.55	Dwell proportion of rear mirror	-0.37	Transition entropy	0.53