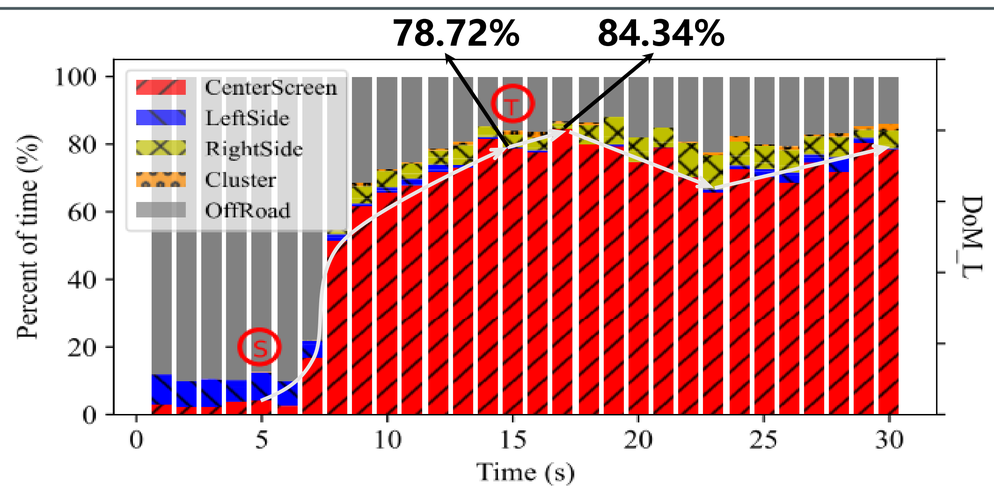
Predicting Readiness and Performance of a Driver for Transitions from Automated to Manual Driving

Introduction

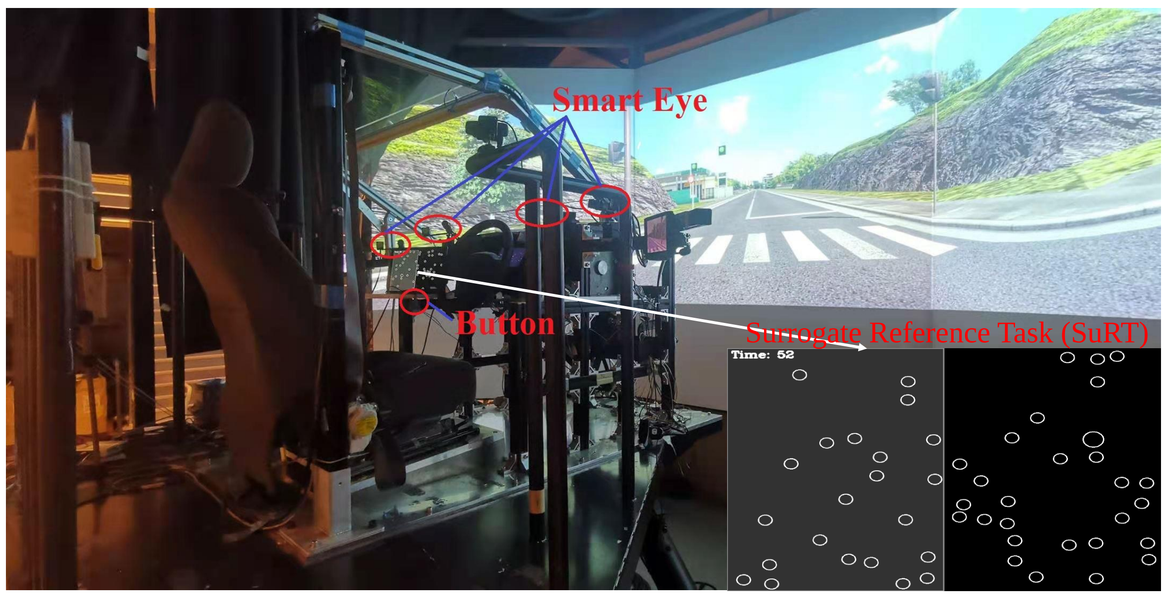
In level 3 automated driving, a fallback ready user is necessary, that should be responsive to system's request to intervene and respond appropriately. This is a challenging task in that it is difficult to decide the sufficient time for a driver to safely take over the vehicle. The **main goal** of this research is to **model drivers' takeover behaviors** by integrating a variety of factors (including system-related, scenario-related, and human-related factors), so that drivers' takeover behaviors could be predicted in advance and systems could adapt their strategies accordingly to ensure safe takeovers.

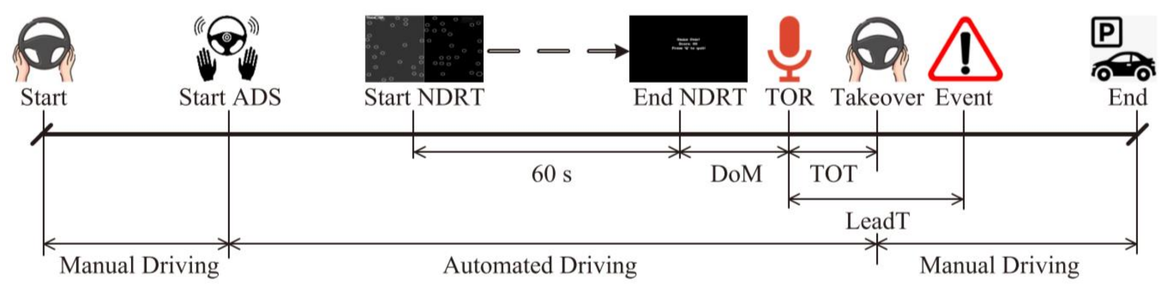


Relatively high level of **PRC** (Percentage of eye gazes on Road Center) leads to **better** and **quicker** decisions. However, if PRC is **too high**, the effect may also be **counterproductive**.

Take-over Experiment

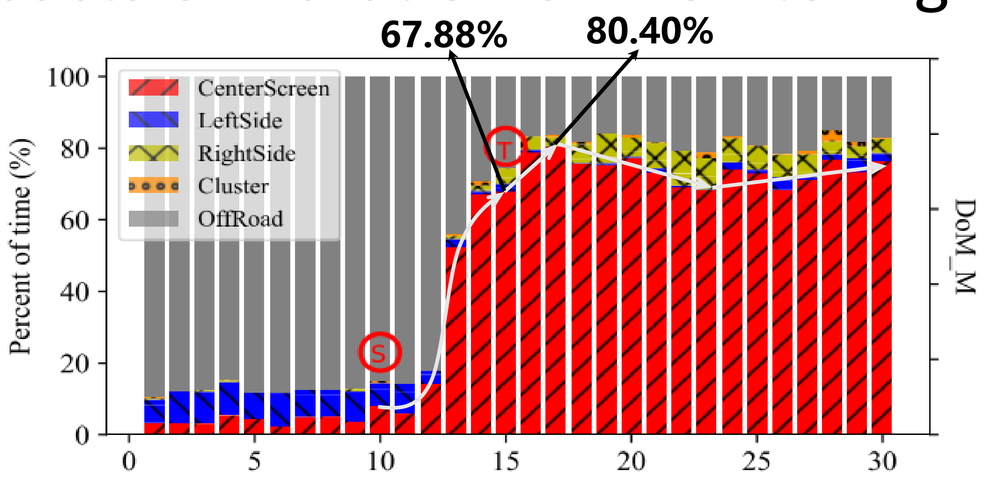
Approved by Ethics Review Committee, NO 17-14





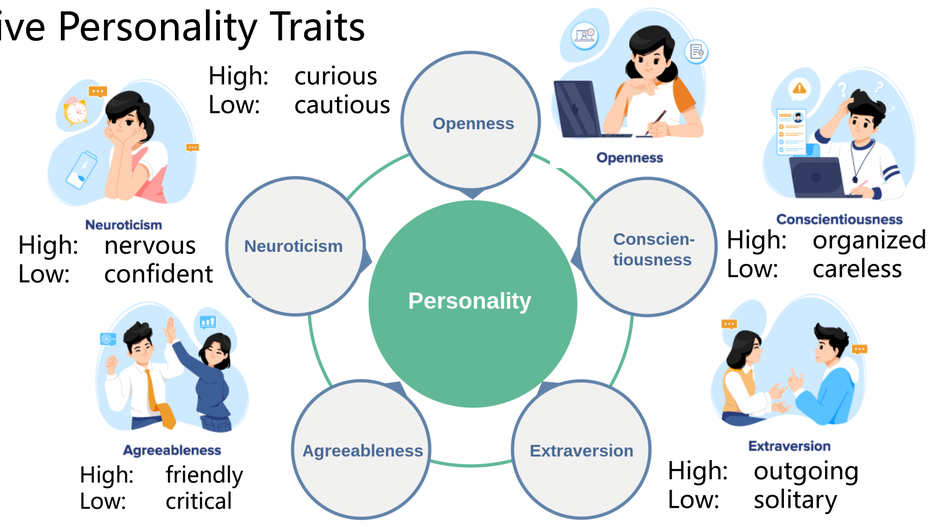
	Scenarios	Symbol	Schematic
High-Critical Scenarios	Sudden braking	TOR1	
	Dropped cargo	TOR2	
	Near merging (left)	TOR3	
	Near cut-in (right)	TOR4	
	Thick fog	TOR5	
	Construction site	TOR6	

Impacts of Duration of Monitoring



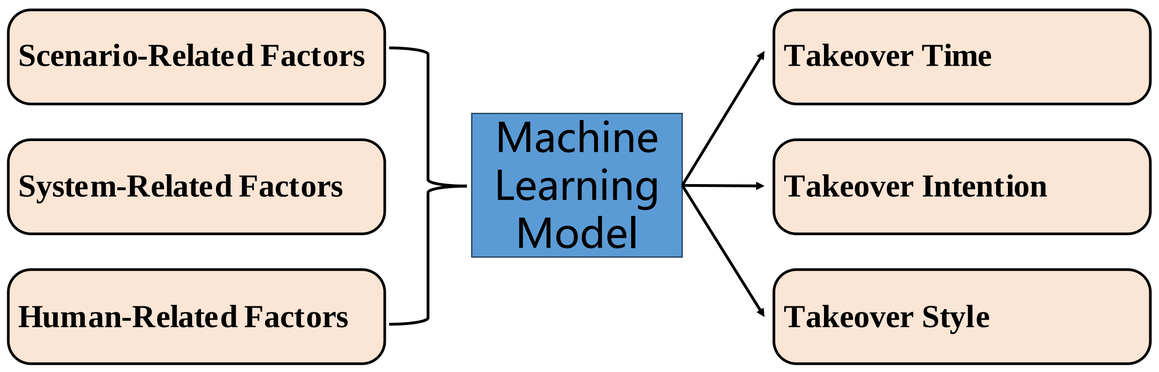
Impacts of Personality

Big Five Personality Traits



Different personality traits affect drivers' takeover performance in different ways. To be specific, **neuroticism** mainly affects **longitudinal** performance, **agreeableness** mainly affects **lateral** performance, and **extraversion** and openness mainly affects **takeover time**.

Modeling Drivers' Takeover Behaviors



- **Modeling Takeover Time**
  - The objective is to model it as a **regression problem**, and XGBoost regressor yields the best performance, with mean absolute error less than 0.5 s.
- **Modeling Takeover Readiness**
  - The objective is to model takeover readiness as a **classification problem**, and XGBoost classifier yields the best performance, with both accuracy and recall over 95%.
- **Modeling Takeover Style**
  - The objective is to model takeover style as a **clustering problem** using time series clustering methods, and DTW (dynamic time warping)-based k-means clustering results in three distinctive patterns of takeover maneuvers regardless of scenarios and DoM.

Publications

Huang, C., Yang, B. and Nakano, K., Accident Analysis & Prevention, 185:107018, 2023. doi: 10.1016/j.aap.2023.107018.
Huang, C., Yang, B. and Nakano, K., Traffic Injury Prevention, 24(7):599–608, 2023. doi: 10.1080/15389588.2023.2224910.
Huang, C., Yang, B. and Nakano, K., IEEE Transactions on Intelligent Transportation Systems, doi: 10.1109/TITS.2024.3389684.

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