

Development of Attribute-Based Driver Models Using a Driving Simulator

- (First Report) Development and application of driver models for cornering -

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Vehicle ECU calibration and testing can be performed efficiently in virtual environments such as SILS and HILS; however, driver models used therein are often implemented as predetermined control logics (e.g., fixed throttle or simple target-speed following) and do not adequately emulate real human drivers. Using a driving simulator (DS) to incorporate real drivers' control actions into virtual tests is effective but recruiting subjects and scenes requiring prolonged driving impose substantial burdens. This study proposes extracting driving-operation features from DS by demographic attributes (e.g., age) and constructing driver models reflecting those features to enable fully virtual evaluations including drivers.

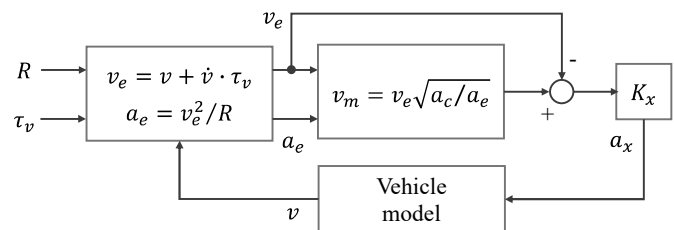
Data were collected on a small DS with a six-axis hexapod motion base and three monitors on a closed circuit (~2.8 km, eight corners). For cornering, we adopted a driver model described by a predicted time (corresponding to forward gaze) and allowable lateral acceleration (Fig.1). Measurements and an eight-item attribute questionnaire (gender, age, license years, driving frequency, DS experience, etc.) were conducted for 41 subjects.

Single attributes did not clearly separate predicted time and allowable lateral acceleration distributions, so hierarchical clustering was applied. Age combined with driving frequency produced the clearest two-cluster separation, defined as "Frequent older drivers" and "Occasional young drivers"; medians of predicted time and allowable lateral acceleration in each cluster were used as model parameters.

To validate the models, we implemented a virtual ADAS that issues a screen warning at the predicted time point when corner entry speed could exceed allowable lateral acceleration. Warning behavior was tuned using three models: DM_N (tuned to match subjects' natural warning frequency), DM_O (Frequent older drivers), and DM_Y (Occasional young drivers). The evaluation was conducted with 21 participants, and the proportion of warning display time (E), defined by the equation below, was used as the annoyance measure for the simulated ADAS function (larger values indicate greater perceived annoyance).

$$E = \frac{|E_{DM_X} - E_{DM_N}|}{E_{DM_N}} \quad \begin{array}{l} E_{DM_X} : \text{Warning Ratio at DM_O or DM_Y} \\ E_{DM_N} : \text{Warning Ratio at DM_N} \end{array}$$

From Fig.2, 3, E tends to decrease with DM_Y for participants in the '25–34' age group and those who 'rarely drive'. Conversely, E tends to increase slightly with DM_Y for participants in the '45–54' age group and those who 'drive about once a week'. These results demonstrate that using attribute-specific driver models for tuning can enable provision of ADAS functions that are acceptable to the target user segments.



R : turning radius, τ_v : predicted time, a_c : allowable lateral accel, a_e , v_e : longitudinal accel. and vehicle speed at predicted time v_m : target vehicle speed, a_x : longitudinal accel.

Fig.1 Driver model for vehicle velocity control in corner

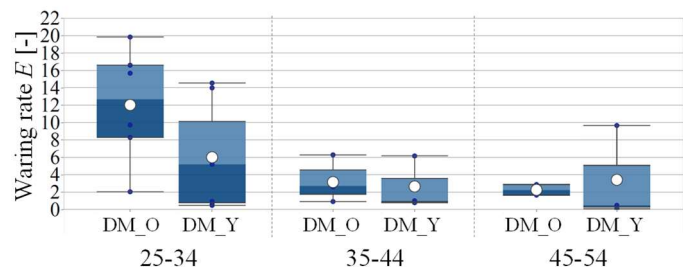


Fig.2 ADAS Warning rate E ((2) Age)

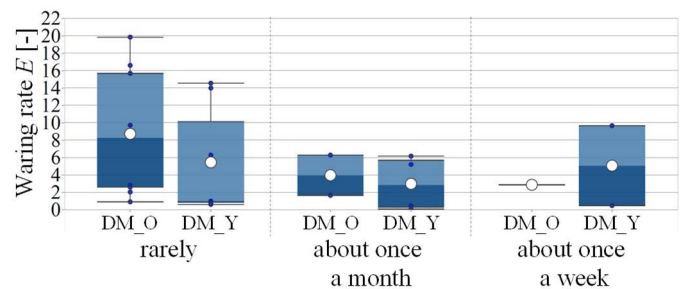


Fig.3 ADAS Warning rate E ((5) driving Frequency)