

Analysis of Large-Scale Real-World Driving Data for Prediction of Vehicle Dynamics on Arbitrary Driving Routes

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Road-test driving conditions in vehicle development are often defined based on past experience and may not adequately represent market driving. This creates a need for accurate simulation under actual driving conditions. To support realistic reconstruction of time-series vehicle dynamics, this study analyzes large-scale real-world driving data to quantify acceleration transitions toward target speeds defined for each road and to clarify their dependence on vehicle attributes.

Connected-car data collected from Toyota vehicles in the Japanese market were used. The dataset includes more than 3 million trips from more than 300,000 vehicles, collected throughout the year across Japan. Vehicle speed was recorded at 1 Hz. All data were anonymized and statistically aggregated with user consent.

An acceleration or deceleration period was defined as one event, with start time t_s , end time t_e , start speed v_s , and end speed v_e . For each event, the speed change from v_s to v_e was divided into ten equal intervals:

$$v_k = v_s + \frac{k}{10}(v_e - v_s) \quad (k = 0, \dots, 10)$$

The time t_k at which the measured speed reaches v_k was obtained by linear interpolation. The average acceleration over the interval was then calculated as

$$a_k = \frac{v_k - v_{k-1}}{t_k - t_{k-1}} \quad (k = 1, \dots, 10)$$

The relationship between v_k and a_k was investigated among vehicle groups classified by powertrain, drivetrain, and vehicle size, as listed Table 1. In this paper, representative results for launch acceleration ($v_s = 0\text{km/h}$, $v_e = 50\text{km/h}$) are shown.

As shown in Fig. 1, for all vehicle groups, acceleration was high near the start of the event and gradually decreased as speed approached the end speed. While the overall profile shape was similar among groups, as shown in Fig. 1(a), the battery electric vehicle group (ID 4) showed a markedly higher acceleration at $v_1 = 5\text{km/h}$, approximately 50% higher than that of the internal-combustion vehicle group (ID 1). This trend is considered to reflect the strong torque characteristics of electric motors at low speed.

The result demonstrate that big real-world driving data can quantitatively capture acceleration transition characteristics as a function of speed and can reveal differences across vehicle attribute groups. These findings provide a basis for more realistic prediction of vehicle dynamic characteristics on arbitrary routes. Future work includes analysis of deceleration behavior, other start/end speed conditions, and the effects of time and location.

Table1 Vehicle specifications

ID	Powertrain	Drivetrain	Weight [kg]
1	ICE	FWD	940-1,020
2	ICE	4WD	1,100-1,130
3	HEV	FWD	1,050-1,090
4	BEV	FWD	1,830-1,920
5	FCEV	RWD	1,920-1,990
6	ICE	4WD	2,500-2,560

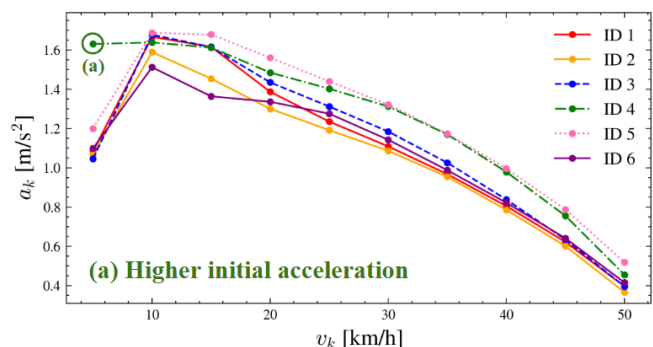


Fig.1 Acceleration profiles by vehicle attribute