講演番号	225

Effect of Acceleration and Deceleration Characteristics of Electric Vehicles on Pedal Operation of Elderly Drivers

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KEY WORDS: **Human engineering, Elderly person, Driver behavior, Electric vehicle, Pedal application** [C2]

Electric vehicles (EVs) and hybrid electric vehicles (HEVs) provide more responsive accelerator control than conventional internal combustion engine vehicles, enabling rapid acceleration and deceleration. In some models, regenerative braking allows deceleration and even complete stopping to be achieved using only the accelerator pedal (one-pedal driving). Because the control characteristics of these vehicles differ substantially from those of conventional vehicles, they may feel unfamiliar to drivers accustomed to internal combustion engine operation. This unfamiliarity may increase the risk of accidents, particularly among older drivers with declining cognitive and physical abilities.

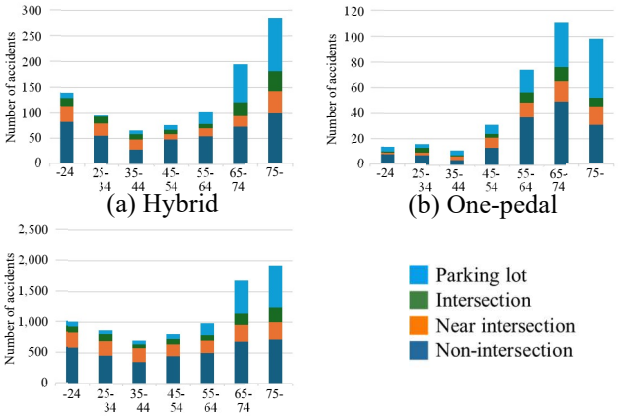
In this study, we analyzed data on pedal misapplication accidents involving elderly drivers to identify human factors and situational characteristics. In addition, driving simulator (DS) experiments were conducted to examine how the acceleration and deceleration characteristics of electric vehicles, as well as pedal operation, affect the driving behavior of elderly drivers.

The accident data analysis revealed that pedal misapplication is particularly common among elderly drivers on non-intersection and in parking lots. A notable trend was also observed in situations involving one-pedal driving, where both acceleration and deceleration are controlled solely through the accelerator pedal via regenerative braking. These findings suggest that such accidents may be influenced by the unique acceleration–deceleration characteristics of electric vehicles and the operational characteristics of one-pedal driving.

The driving simulator experiments further showed that one-pedal driving resulted in greater variability in vehicle speed and accelerator pedal opening compared to other vehicle types, indicating increased operational difficulty. In particular, elderly drivers exhibited larger fluctuations in accelerator pedal opening, suggesting that pedal control may be affected by age. In addition, the time-to-collision index (iTTC) tended to be higher under one-pedal driving conditions, indicating an increased risk of collision with a leading vehicle. However, for both age groups, the average following distance under one-pedal driving was greater than that observed with other vehicle types at speeds below 30 km/h, suggesting that drivers may adopt more cautious behavior when they perceive instability in vehicle control.

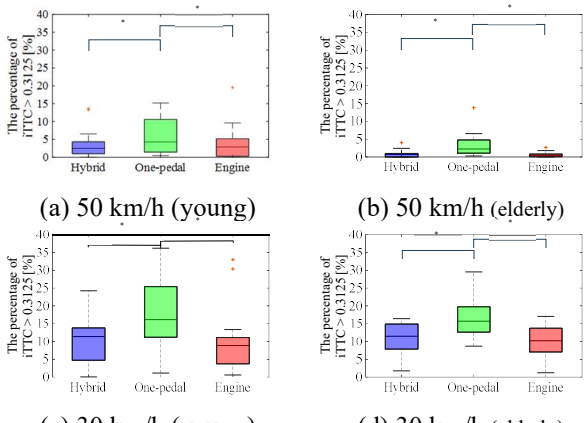
During deceleration, greater variability in relative speed was observed under one-pedal driving, particularly during gentle deceleration. Furthermore, when the deceleration rate changed during the maneuver, variability increased, especially among elderly drivers. These results indicate that one-pedal driving can be difficult to control under certain conditions, and that this difficulty is more pronounced in older drivers.

In conclusion, when operating electric vehicles, including those equipped with one-pedal systems, it is essential for drivers to fully understand the vehicle's acceleration and deceleration characteristics, including regenerative braking, and to adapt their driving behavior accordingly. At the same time, improvements in safety are expected through vehicle-based assistance systems, such as control mechanisms that moderate acceleration and deceleration in speed ranges where operation tends to become unstable.



(a) Hybrid (b) One-pedal (c) Passenger car

Fig.1 Number of brake and accelerator misapplication, by age group and location



(a) 50 km/h (young) (b) 50 km/h (elderly)

(c) 30 km/h (young) (d) 30 km/h (elderly)

Fig.2 Distribution of percentage of iTTC > 0.3125