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A Survey on Driving Characteristics during Braking for Enhancement of Adaptive Cruise Control system

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Abstract. Adaptive cruise control (ACC) system Cruise Control is one of advanced driver assist systems (ADAS) for road vehicles. ACC systems have been designed and commercialized based on only ISO standards. ADAS needs more detailed design criteria. In this study, few parameters representing driving characteristics are drawn and the criteria for classification are suggested by securing and analyzing 77 driver vehicle interaction databases for highway driving. Drivers are classified by the suggested criteria and decelerating characteristics of each class are analyzed. Needs of discriminative standards considering an individual driver's driving characteristics for designing ACC algorithm are asserted in consideration of the analysis.

Keywords: Adaptive Cruise Control, TTC, TimeGap, Field Operational Test

1 Introduction

Many car makers have been trying to commercialize adaptive cruise control (ACC) system. To commercialize ACC system, algorithms of the system have been designed in accordance with only few ISO standards. Those standards are designed by considering only safety issues although the standards should be based on both safety and convenience. ACC is not a system for convenience, but only a safety system. Most drivers can feel worse in such situations, too. Therefore, more detailed standardization is needed to satisfy issues on safety and convenience.

In this study, few parameters representing driving characteristics are drawn and the criteria for classification are suggested by securing and analyzing 77 driver vehicle interaction databases. In results, needs of discriminative standards considering an individual driver's driving characteristics for designing ACC algorithm are asserted.

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2 Driver Vehicle Interaction Database (DVI DB)

2.1 Driver Vehicle Interaction Database (DVI DB)

Parts of driver vehicle interaction database (DVI DB) are analyzed to validate the needs of discriminate criteria for designing ACC algorithm. The database is measured in various road environments: highways, national routes and local routes. About 700 hours and 35,000 kilometers of database have been secured.

2.2 Comparison between practical driving characteristics and ISO standards

77 drivers are selected to be analyzed. Deceleration levels for most drivers are around – 0.05g's less than -0.25g's suggested in ISO standards. Although all the cases of braking situation are under the ISO standards, the suggested level of deceleration, -0.25g's, is too big for most cases of braking. This means that drivers must feel uncomfortable in most of cases during activating deceleration process. Therefore, it is needed that the ACC activation algorithm is practically designed.

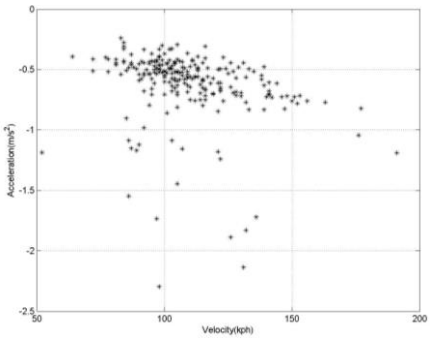


Fig. 1. Deceleration distribution in practical braking

3 Analysis of Driving Characteristics

3.1 Classification of drivers

In this research, drivers are classified based on cruise velocity setting and time gap setting of conventional ACC system. To define criteria for classification of drivers, driving data of 77 drivers are surveyed.

First, drivers are classified by mean speed during cruising on straight roads conditions without any preceding vehicles. 61 drivers are finally selected by sorting abnormal drivers out as surveying evaluated data.

Table 1. Classification of drivers based on cruising velocity

Cruising velocity	No. of drivers
Under 100kph	28
Between 100 and110 kph	24
Over 110 kph	9

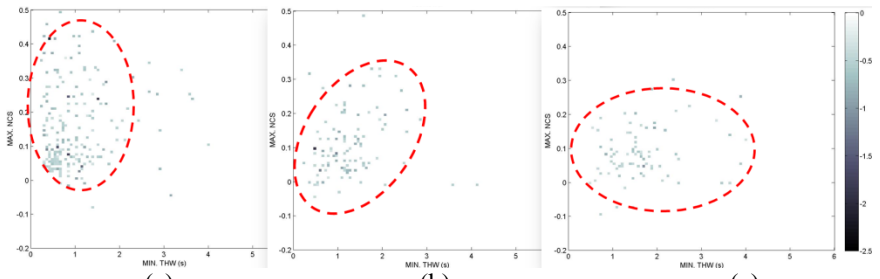
Second, the 61 drivers selected for first criterion are classified in consideration with time gap setting of conventional ACC system. This classification criterion is defined by analyzing maintaining characteristics of distance to a preceding vehicle when cruising.

Table 2. Classification of drivers based on time gap level

	TimeGap levels		
	Under 1.5	1.5 ~ 2.5	Over 2.5
Linear distribution	11	25	14
Scattered distribution	0	3	8

The finally selected 50 drivers are classified in 9 segments based on the criteria explained above.

Human drivers reduce speed because of a relative speed and distance to a preceding vehicle. Maximum values of near closing speed and minimum values of time headway for all the cases of braking are shown in fig 2. The contour presents the levels of deceleration for each case. More frequent braking action, the bigger deceleration values and the bigger NCS values can be seen for a group classified in smaller time gap. In the group of bigger time gap level, drivers tend to reduce speed for smaller NCS values. Drivers who set smaller time gap level tend to not only avoid braking action, but also make bigger levels of braking if they want to reduce speed.

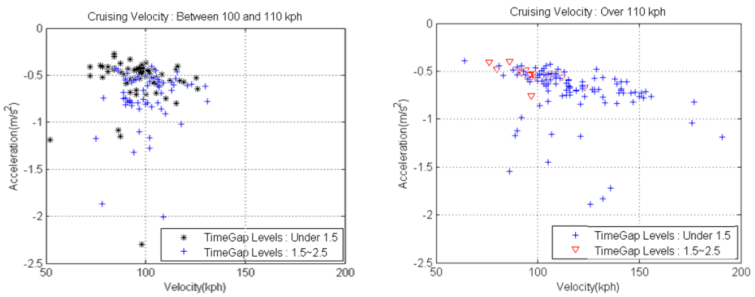


(a) (b) (c)

Fig. 2. Distributions of NCS vs. THW for groups classified by time gap levels: (a) time gap less than 1, (b) time gap between 1.5~2.5, (c) time gap bigger than 2.5

Different distribution of deceleration versus vehicle speed as setting time gap levels differently are shown in fig. 3: (a) groups for cruising velocity between 100kph and 110kph, (b) groups for cruising velocity over 110kph. It can be seen that groups of higher level of time gap with the higher cruising velocity reduce speed more softly than the other groups on the similar velocity, e.g. differences deceleration levels

between the group for time gap levels under 1.5 and the group for time gap levels over 1.5 around 100kph. Therefore, it means that operating ACC system with smaller values of deceleration is needed for drivers who desire higher setting of time gap level even if they set higher cruising velocity.



(a) (b)

Fig. 3 Distributions of deceleration vs. vehicle speed: (a) cruising velocity between 100kph and 110kph, (b) cruising velocity over 110kph

4 Conclusions

Specific criteria are suggested to classify drivers. It is found that design criteria of ACC system presented in ISO standard are not quite fit for Korean drivers. Most of deceleration levels are around -0.05g's much less than the maximum deceleration levels presented in ISO standard. Reasons, times and levels of braking are different from each other group as well. This paper suggests that decisions of deceleration, levels and variations have to be variable considering cruise velocity and time gap level set by individual drivers for designing ACC algorithms.

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