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Design for AEBS Test Scenario Applying Domestic Traffic Accidents

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Abstract

This study is a study on the development of AEBS test scenarios for traffic accidents in Korea, and was compared and analyzed using the Traffic Accident Analysis Program. To ensure the safety of passengers and pedestrians in traffic accidents, the number of cars equipped with ADAS is increasing rapidly at all car manufacturers in each country. For traffic accidents used in this study, the domestic traffic accident database (ACCC) produced by SAMSONG was used. Domestic traffic accidents differ from overseas traffic accidents in terms of road type, signal system, driver's seat location and number of vehicles. ACCC databases, which supplemented and reinforced these differences, built a database based on the PC-CRASH program. In the study, we analyze the types of accidents to develop comparative scenarios for each type of road and collision type of traffic accidents. When the road types of traffic accidents in Korea were divided into five types and the collision types were divided into six, it was confirmed that the most types of FRONT-SIDE crashes appeared at the intersection. It is expected that the frequency of possible traffic accidents and collision types can be predicted according to the road type in the accident database, we that it can be used as an AEBS test scenario development suitable for the domestic road environment.

Keywords: *Traffic Accidents, PC-Crash Program, Collision Speed, Collision Angle*

1. Introduction

In order to prevent and mitigate the safety of occupants and pedestrians in traffic accidents, and to prevent and mitigate accidents, the number of automobiles equipped with ADAS is rapidly increasing in all automobile manufacturers in each country. The reason ADAS has been widely spread is to achieve a safety rating of 5 stars in the EURO NCAP (European New Car Evaluation Program) and to strengthen the competitiveness of products in the upcoming autonomous vehicle market. In the European New Car Evaluation Program, from 2016, it is classified as an emergency braking system evaluation scenario, AEBS (Advanced Emergency Braking System) among ADAS devices. Began to lose. Related research is the NHTSA (National Accident Sampling System) of the United States.

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CIREN, CISS, LTCCS, etc., in the UK, OTS (On The Spot investigation Network), Germany in GIDAS (Germany In-depth Accident Study), IGLAD (Initiative for the Global Harmonization of Accident data), etc. Similarly, in-depth analysis is being carried out by establishing a traffic accident database abroad [1]. Through the domestic bicycle traffic accident database, a representative type considering the severity of accidents was presented as a focus analysis of detailed accident types required for verification scenario development [2], and K-CITY community roads using traffic accident data and text mining techniques. It was suggested that the self-driving car scenario developed through this method can be used in real-car experiments [3].

In addition, the collision type was classified as a combination of traffic accident road type and accident type, and the scenario was composed and entered as the driving route of MILS and VILS to verify whether the autonomous driving control event was intervened, and the right-hand drive vehicle was operated on domestic roads. The result was that it was necessary to cope with various problems, operation errors, and accident types that occur frequently [4, 5]. In a traffic accident, a system was proposed to install a driving information check device for car insurance and to verify driving information with a smartphone [6]. The application of the driver's system for traffic safety in developing countries where traffic accident databases have not yet been established was proposed, and even if all of Euro NCAP's AEBS evaluations were satisfied, the results of the application to domestic traffic accidents showed different results [7, 8]. The Delta-V measurement method was proposed to evaluate the severity of accidents by establishing an in-depth traffic accident database, and it was suggested that the detection range of Vision and Radar sensors needs to be improved according to the accident scenario at the intersection [9, 10]. A lot of victims occur due to traffic accidents in frozen areas due to weather changes in winter in Korea. After analyzing the freezing area using IoT technology and smart sensors in advance, we propose a technology that detects and transmits the location of the traffic accident using the USN function [11]. In this study, traffic accidents with a high frequency of occurrence are classified by classifying the types of roads and collisions using the domestic traffic accident database based on the difference from domestic traffic accidents such as overseas land area, signal system, driver's seat location, and number of vehicles. And we want to find an AEBS test scenario that fits the domestic road environment.

2. Database and Interpretation

2.1 Traffic Accident Database Construction

In order to establish a database of domestic and overseas traffic accidents, NHTSA of the United States used data from 2017 to 2019 for CIREN, an open database, and from 2016 to 2017 for overseas traffic accidents. We used ACCC (Automotive Collision Case Catalog), which is a database of domestic traffic accidents in SAMSONG. In addition, the domestic traffic accident ACCC is all simulated with the traffic accident analysis program PC-Crash by applying all traffic accident data such as traffic accident situation, vehicle, place, date, occupant, EDR, DTG. The database construction method used Microsoft's DBMS (Database Management System) ACCESS program to convert domestic and foreign traffic accidents into a database.

2.2 Vehicle Crash Mechanics

Figure 1 shows the occurrence of two-dimensional motion, a form of a right-angle collision. The equation that applies the law of conservation of momentum of each vehicle can be expressed as (1) and (2).

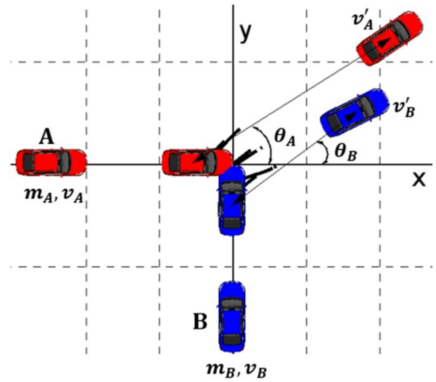


Figure 1. Two-dimensional collision

$$m_A v_A cos\theta_A + m_B v_B cos\theta_B \quad = \quad m_A v'_A cos\theta'_A + \quad m_B v'_B cos\theta'_B \tag{1}$$

$$m_A v_A sin\theta_A + m_B v_B sin\theta_B \quad = \quad m_A v'_A sin\theta'_A + \quad m_B v'_B sin\theta'_B \tag{2}$$

$$V'_A = \sqrt{2 \cdot \mu \cdot g \cdot d_A} \tag{3}$$

$$V'_B = \sqrt{2 \cdot \mu \cdot g \cdot d_B} \tag{4}$$

In Equation (1) represents the component in the X direction, and equation (2) represents the equation in the Y direction. m is the mass of each vehicle, V is the collision speed, V' is the speed after the collision, θ is the entry angle before the collision, and θ' is the departure angle after the collision. The velocity after the collision of V' can be expressed as equations (3) and (4).

μ is the coefficient of friction on the road surface, g is the acceleration due to gravity (*9.80665m/s*^{2}), and d_A, d_B is the distance after collision. Equations (1), (2), (3), and (4) can be used to calculate the pre-collision speed V_A and V_B of each traffic accident. In order to check the pre-collision speed, the speed of ACCC's PC-Crash simulation and the error range through the calculation formula of the above formula were checked. Figure 2 shows the ACCC's PC-Crash simulation speed and the error rate through the calculation formula. When the crash speed is low, the error rate is large, and the error rate range is about *96.64%* for 10km/h or less, and about *75.19%* for 5km/h or less. The error in calculating the crash speed through the PC-Crash simulation speed and calculation formula. It can be seen that this is not large.

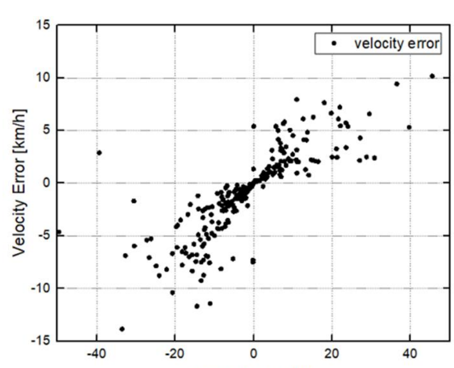


Figure 2. Collision velocity error rate

2.3 Database Classification

Traffic accidents ACCC and NHTSA data were converted into a database using only vehicle-to-vehicle traffic accidents excluding vehicle-to-pedestrian, vehicle-to-bicycle, and motorcycles as an ACCESS program through Python program crawling. Among the classification methods, road types were classified into curved roads, intersections, straight roads, and others, and collision types were classified into Front-Side, Front-Rear, Front-Front, and others. ACCC is a domestic traffic accident and NHTSA is an overseas traffic accident. It was confirmed that about *90%* of traffic accidents excluding other (single accidents), including domestic and overseas, were occupied at intersections and straight roads. In addition, collision-type accidents of Front-Side at intersections and Front-Rear at straight roads are higher than those of other accidents, which are similar in Korea and abroad. Collision accidents like Front-Rear were excluded because there was an existing AEBS scenario, and through this, the Front-Side collision type at intersections and straight roads was selected. Domestic traffic accidents ACCC and overseas traffic accidents NHTSA CIREN are PC-Crash simulations, but NHTSA's CISS is a large amount of the collision speed and The collision angle was derived. Figure 3 shows the collision speed and collision angle only for the collision type of traffic accident ACCC, NHTSA intersection and front-side of straight road. It can be seen that the collision speed occurs most frequently in the range of *10km/h* to *60km/h*, and the collision angle is distributed over the entire section.

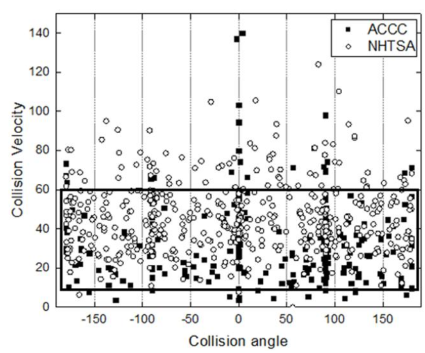


Figure 3. ACCC, NHTSA collision angle and collision rate

2.4 Classification of Domestic Traffic Accident Types

The types of roads classified in domestic traffic accidents are intersections and straight roads. Among the three collision types, Front-Side is the most common, and the corresponding types were analyzed in detail. Figure 4 shows the collision type of the front-side and the frequency of each collision situation in a domestic intersection accident. Collision situations were classified into a total of 10 types, and *28.8%* of the most common right-angle collisions, 1_collision, occur within a range of about *10%* similarly except for collisions of 6, 9, and 10_Collision.

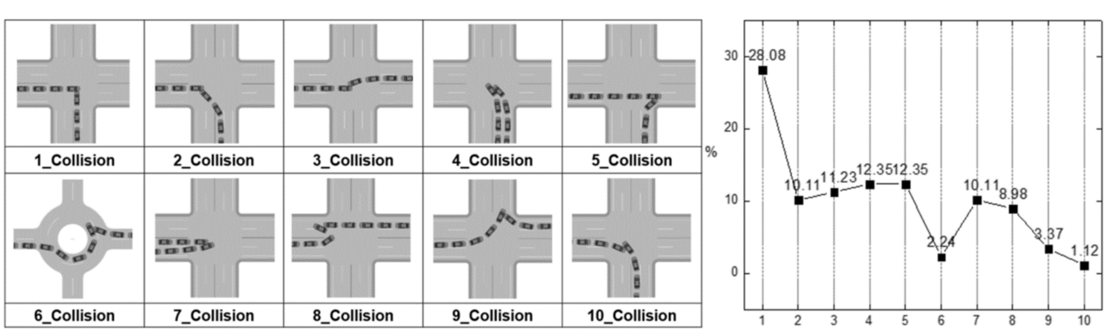


Figure 4. Types of FRONT-SIDE collisions at domestic intersections

Figure 5 shows the collision type of the Front-Side occurring on a straight road. Collision situations on straight roads are classified into five categories, and it appears to occur most often when changing lanes, which are 1, 2, 3, and 4 collision situations. As a result of classifying the collision types of the Front-Side occurring at intersections and straight roads, it can be seen that 1_Collision at intersections and 2_Collision at straight roads occur more than other collision situations.

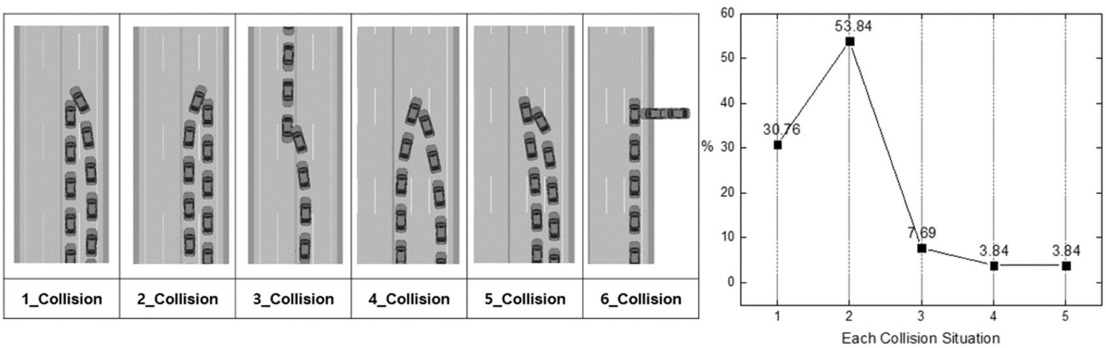
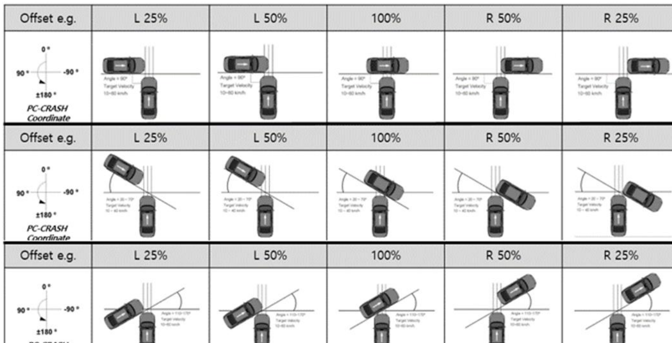


Figure5. Types of FRONG-SIDE collisions at domestic straight roads

3. Results and Discussion

Intersection accident analysis results of domestic traffic accidents Table 1. It is expressed as The vehicle facing up to 0º is the test vehicle (T-Car), and the vehicle applied by angle is the GVT (Global Vehicle Target) vehicle. In the case of a right-angle collision with the highest frequency in an intersection traffic accident, the collision angle between the T-Car and GVT is 90º, and the collision speed is shown in the figure. As shown in 3, at a speed of *10~60 km/h*, increasing by *10 km/h* steps, L(Left) *25%, 50%,* R(Right) *25%, 50%* based on the center of GVT. In addition, *100%* OFFSET was applied to the center collision of GVT. The total number of AEBS scenarios in which the speed and offset variables are applied in the right-angle collision is *180*. Table 1. The second scenario in is a scenario that occurs when a GVT vehicle turns left in the opposite lane in front of the intersection. The speed of both T-Car and GVT vehicles is *10~60 km/h*, increasing by *10 km/h steps*, and the collision angle and entry angle of GVT are 20°~60°. In this second scenario, the total number of AEBS scenarios applying the variables of collision speed, collision angle, and offset is *1,080*. Table 1. The third scenario in is a scenario that occurs from the left side of the intersection to *90°* and then a left turn after entering the intersection. In this scenario, the speed of both T-Car and GVT vehicles is *10 to 60 km/h*, increasing by *10 km/h* steps, and the collision angle and entry angle of GVT are *110° ~ 170°* And OFFSET consists of a total of five. In this third scenario, the total number of AEBS scenarios applying the variables of collision speed, collision angle, and offset is *1,260.*

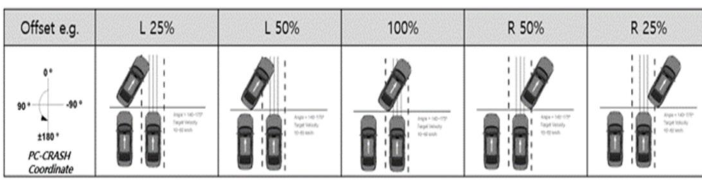
Table 1. AEBS Intersection scenario reflecting domestic traffic accidents



Scenario 1	T-Car Velocity	10 ~60 kph (10')
	GVT Velocity	10 ~60 kph (10')
	GVT Angle	90º
	T-Car Offset	L 25% ~R 25% (25')
Scenario 2	T-Car Velocity	10 ~60 kph (10')
	GVT Velocity	10 ~60 kph (10')
	GVT Angle	20º ~70º (10º)
	T-Car Offset	L 25% ~R 25% (25')
Scenario 3	T-Car Velocity	10 ~60 kph (10')
	GVT Velocity	10 ~60 kph (10')
	GVT Angle	110º ~170º (10º)
	T-Car Offset	L 25% ~R 25% (25')

Table 2. shows the results of analysis of accidents on straight roads in domestic traffic accidents. This scenario is a scenario in which the GVT vehicle on the left changes lane toward the T-Car vehicle. Actually, a lane change accident on a straight road may occur while moving from right to left, but it is determined that the detection angle and detection distance of the sensor characteristics of AEBS are irrelevant to the lane change from the left and right. As shown in *5*, it was set based on 2_Collision, which occurs most often in straight roads. The collision angle variable of the straight road AEBS scenario is from *140° to 175°*, increasing by *5°* steps, and a total of *1,440* straight road AEBS scenarios to which the variable is applied. As a result of applying the scenario variables of intersections and straight roads, about *3,960* AEBS scenarios could be derived.

Table 2. AEBS Straightway scenario reflecting domestic traffic accidents



T-Car Velocity	10 ~60 kph (10')
GVT Velocity	10 ~60 kph (10')
GVT Angle	140° ~175° (5°)
T-Car Offset	L 25% ~R 25% (25')

4. Conclusion

In this study, various traffic accidents occurring at home and abroad were identified, the types of roads and collision types were identified, and the analysis results according to the collision speed and collision angle are as follows.

(1) It was confirmed that more than *90%* of domestic and foreign traffic accidents are similarly occurring at intersections and straight roads.

(2) When accidents at intersections were classified into *10* categories and accidents on straight roads were classified into *5*, it was possible to derive the most common collision situations on domestic roads. In addition, it was confirmed that there are cases similar to the EURO NCAP CCFTap scenario.

(3) According to the collision speed, collision angle, and offset of AEBS scenarios at intersections and straight roads according to domestic traffic accident conditions, *3,960* scenarios were developed.

In this study, the results of the AEBS scenario development among ADAS devices that prevent and mitigate traffic accidents are presented. It is expected that it can be used as a standard for reducing traffic accidents through the AEBS scenario in which the most common intersection and straight road accidents are applied.

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