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Research on AEB Control Strategy Based on Typical Test Scenarios

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Abstract

AEB (Automatic Emergency Braking) is an active safety technology. According to the estimation of the vehicle's collision risk, the vehicle automatically implements the braking by controlling the vehicle's braking mechanism to avoid or reduce the severity of the collision. The analysis of the CAN bus signal is a necessary method to deeply study the internal control strategy of the vehicle. Research on the AEB control strategy based on CAN bus signal analysis is beneficial to promote AEB control technology, and at the same time, it is helpful to improve the benchmarking technology level of self-owned brands. Taking the AEB test of an advanced vehicle as an example, this paper introduces the technology of test program design, parsing CAN bus signals and key test equipment installation, which is of great significance for improving the research level of the vehicle AEB control strategy.

Keywords

AEB test; Control strategy; CAN bus; Test scenarios construction; Benchmarking.

1. INTRODUCTION

In recent years, automatic driving has gradually become the focus of research and development investment of car companies, which also are paying more and more attention to Advanced Driver Assistance System (ADAS). AEB, an important active safety system of ADAS, whose configuration rate is constantly increasing in recent years, and will become a necessary configuration for self-driving cars in the future. In terms of standards and regulations, the E-NCAP, C-NCAP and other new vehicle evaluation protocols have incorporated AEB into the evaluation program. This means that cars without AEB will not receive a five-star rating [1-2].

At present, major automobile manufacturers in the world are developing their own collision and pre-collision systems. Because of the different terms of each manufacturer, the final results and application details are also different. The development of AEB system in major domestic OEMs is still in the preliminary stage. The current development mode is mainly to supply the system directly from foreign suppliers, and at the same time, to explore and build the independent development capability of the system step by step.In the current background, how to benchmark the first-class enterprises in the industry and quickly improve the technical level of this enterprise has become a difficult problem faced by all enterprises. Many standards, regulations-making departments and relevant testing organizations have issued corresponding AEB test and evaluation specifications, but there are still few benchmarking tests for AEB control process and control strategy within the industry [3-4].

Under the background of insufficient benchmarking test depth, this paper designs AEB system test scenarios and test methods, which greatly improves the benchmarking depth and

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the visibility of test results, which is of great significance for improving the ability of independent research and development.

2. RESEARCH ON BENCHMARK TEST METHOD OF AEB CONTROL STRATEGY BASED ON REAL VEHICLE TEST

2.1. Overall Test Program Design

AEB system test has high accuracy requirements for the longitudinal and lateral positions, speed and deceleration of the test vehicle and the target vehicle. In order to ensure the accuracy and repeatability of the test, a professional test system should be used for the test. As shown in the Figure 1, the overall test system is mainly composed of the test vehicle control system, the target vehicle control system, the RT base station, and the CAN bus signal analysis system, etc [5].

The test vehicle is equipped with the AEB system, and the target vehicle in front of the test vehicle is identified as an obstacle by the test vehicle‘s AEB system. The atuo-driving robot installed in the test vehicle and the target vehicle are used for automatic driving during the test. Vehicle-mounted inertial navigation provides position and navigation information for driving robot. The communication device can transmit the speed and position information of target vehicle to test vehicle through wi-fi antenna, and calculate the relative distance, relative speed and collision time of two vehicles. The CAN bus signal analysis system reads and records the CAN bus data of the test vehicle in real time through CANoe. After CAN bus signal analysis, various state data of the test vehicle can be obtained.

In order to analyze the AEB control strategy more deeply, it is necessary to extract various vehicle status data from the CAN bus. Considering the signal characteristics and the specific difficulty of CAN bus signal decoding, the relevant test signals and data acquisition methods in this test are shown in Table 1.

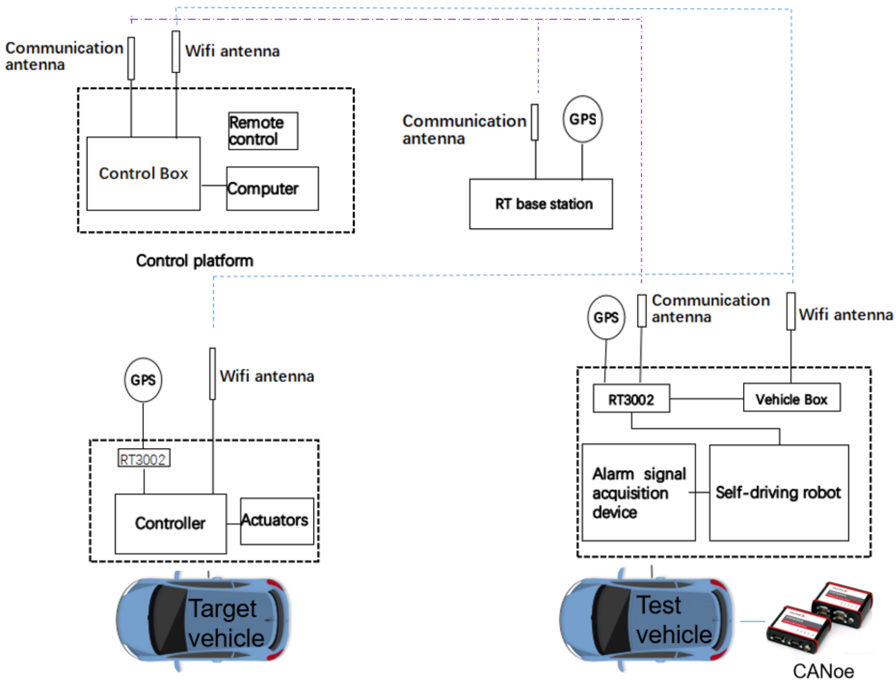

Figure 1. AEB Test System

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Table 1. Signal list

NO.	Signal name	number	Signal source
1	Speed	1	Can bus
2	Actual acceleration	1	Can bus
3	Braking state	1	Can bus
4	Driver braking state	1	Can bus
5	Brake pressure of wheel cylinders	4	Can bus
6	AEB event status	1	Can bus
7	Sound alert status	1	Test device
8	TTC	1	Test device
9	The relative distance	1	Test device

2.2. Research on Parsing CAN Bus Signals

CAN (Controller Area Network) is a communication network widely used in vehicle control system. In the reverse analysis, most of the signals are in the power CAN, and some are in the chassis CAN or other CAN buses. In reverse analysis, many diagnostic signals are also used to supplement the signal information that cannot be reverse parsed. Generally, the OBDII port of vehicle is not encrypted, and 6 PIN is usually used for CAN_ H. 14 PIN is CAN_ L. Sometimes there are 3-11 PIN and 1-9 PIN, which should be determined by bus voltage, resistance and signal test according to the actual vehicle conditions.For vehicles with encrypted OBDII port, it is necessary to obtain communication message through breaking the line.

CAN bus signals are generally divided into real-time communication signals and diagnostic signals.Among them, the real-time communication signal is analyzed through the can message actually sent by the vehicle, which is difficult because of the large amount of messages and fast update speed; The diagnostic signal uses the question and answer mode of the diagnostic instrument. The signal can be sent separately for screening. The disadvantage is that the access and response time is relatively long and the signal update speed is slow.The following methods can effectively help decode CAN signals.

1) Observation method

It is suitable for signals with obvious static change, such as accelerator pedal signal.It can be found in observation that when the accelerator pedal is depressed, the value of an ID will gradually increase, and when the oil is collected, the value will decrease, and the accelerator pedal signal can be confirmed by repeating this process.The speed and acceleration signals can be confirmed by the same method.

2) Synchronization method

This method is suitable for dynamic and fast-changing signals,such as engine speed. Firstly, through the engine start-stop control, find the ID that matches the engine action. Secondly, use the diagnostic instrument and CANoe to record the data curve at the same time. By comparing the two graphs, it can be judged whether the change trend of the curve is consistent, so that the signal can be preliminarily determined.

3) Curve tracking method

In the process of signal decoding, a number of follow-up bytes will be observed in several ID messages after the driver performs an action, but it is difficult to see the obvious rule of these data. At this time, we can place these signals in the Graph window of the CANoe software to observe the real-time changes of the curve, and find the relationship between the curve changes and the actions performed. For example, signals related to vehicle steering.

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2.3. Test Scenarios Design

At present, C-NCAP, E-NCAP and related papers have made a detailed description of AEB test and evaluation methods, test scenarios and test parameters[6-7].According to C-NCAP, The AEB test scenarios are mainly divided into 'Car-to-Car Rear Stationary' and 'Car -to - Car Rear Moving', etc. In order to study the vehicle AEB control strategy, we can expand the scenario based on the test experience. On the one hand, we can study the control strategy of AEB in standard test scenarios, and on the other hand, we can benchmark its vehicle performance limits. The test scenarios are summarized in this paper as shown in Table 2.

Car-to-Car Rear Stationary(CCRs):When the target vehicle is stationary, the speed range of the test vehicle is from 30km / h to the maximum collision avoidance speed. During the test, the target vehicle is stationary on the driving path of the test vehicle, the test vehicle runs according to the planned path without manual braking, and there is 100% overlap between the two vehicles. The braking control strategy of the test vehicle under AEB condition is explored through gradual acceleration.

Car -to - Car Rear Moving(CCRm): In this section, we mainly pay attention to the test under the working conditions that the target vehicle operates at a constant speed and the test vehicle speed is from 50km/h to the maximum collision avoidance speed. During the test process, the test vehicle and the target vehicle drive along the planned path. The target vehicle drives at a constant speed of 20 km/h, and the test vehicle does not apply manual braking during the whole process, with the two vehicles overlap 100%. Through step-by-step acceleration, explore the braking control strategy of test vehicle under AEB.

Table 2. Test scenarios

NO.	test scenarios	the speed of the test vehicle (km/h)	the speed of the target vehicle (km/h)
1	CCRs	30	0
2		40	
3		50	
4		Maximum speed of avoiding collision	
5	CCRm	50	20
6		60	
7		70	
8		Maximum speed of avoiding collision	

3. TYPICAL CASE ANALYSIS

3.1. Test Equipment Installation

As shown in Figure 2, the corresponding test equipment is installed inside and outside of the vehicle according to the test scenarios design. The inertial navigation equipment is installed at the vehicle centroid inside the test vehicle, and two GPS antennas are placed on the centerline behind the roof and in front of the roof, respectively. The target vehicle is replaced with a dummy vehicle that moves forward, steers, and brakes under the action of the load-bearing motion platform. Set up a differential station,install the auto-driving robot at the driver's position, and install the camera and alarm signal acquisition device at the same time. According to the basic structure of the vehicle, locate the vehicle power CAN, chassis CAN, body CAN and ADAS CAN, and pierce the wire with a probe to connect CANoe devices.

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Figure 2. Equipment Installation Pictures

3.2. Test Data Acquisition and Fusion

After all kinds of equipment are installed, parameter setting and corresponding initialization will be carried out. The CAN bus data of the vehicle and the sensor data are fused and time synchronized through the data acquisition equipment. During the testing process, the test situation can be viewed in real time through the test equipment monitoring platform and CANoe software. At the same time, based on the abundant data collected by the test equipment and CANoe, a more in-depth data analysis can be performed afterwards to summarize the control strategy of the AEB.Before the test, reverse parse a certain number of CAN bus signals in advance, and connect the CAN line to the data acquisition platform equipment through the harness connector. After the test, the test equipment data and CAN bus data of time synchronization can be directly exported. CANoe device can acquire and store more data than the parsed signals.

3.3. Analysis of Test Results

Through the analysis, we can know that the test vehicle senses the road environment ahead through lidar, millimeter wave radar and camera, and warns the driver before the collision. When the driver does not respond to the possible collision, AEB system will intervene to reduce or even avoid the collision.Taking the vehicle speed of 60km / h and 70km / h when the target vehicle is stationary as an example, the AEB braking control strategy of the vehicle is analyzed as follows.

1) 60km/h scenario

Figure 3 shows the change curves of vehicle speed and acceleration. Before the AEB is triggered, the external driving robot steps on the accelerator pedal to control the test vehicle to move forward at a constant speed. After AEB is triggered, the test vehicle will automatically control and brake quickly, with the maximum actual deceleration of $10.16m/s^2$. The sharp reduction time of actual deceleration lags behind the triggering time of AEB by 0.12s.when AEB is triggered, the distance between the test vehicle and the target vehicle is 20.54m. When the test vehicle stops, the distance from the target vehicle is 1.94m, and it takes 3.87s from the sound alarm to the stop. Data statistics of key time points are shown in Figure 4.

2) 70km/h scenario

Figure 5 shows the change curves of vehicle speed and acceleration. Before the AEB is triggered, the external driving robot steps on the accelerator pedal to control the test vehicle to move forward at a constant speed. After AEB is triggered, the test vehicle will automatically control and brake quickly, with the maximum actual deceleration of $10.70m/s^2$. The sharp reduction time of actual deceleration lags behind the triggering time of AEB by 0.12s. Due to the high speed, the test vehicle collides with the target vehicle. When AEB is triggered, the distance between two vehicles is 23.10m. In case of vehicle collision, the vehicle speed is 15.48km/h, and it takes 1.84s from the sound alarm of the vehicle to the collision. Data statistics of key time points are shown in Figure 6.

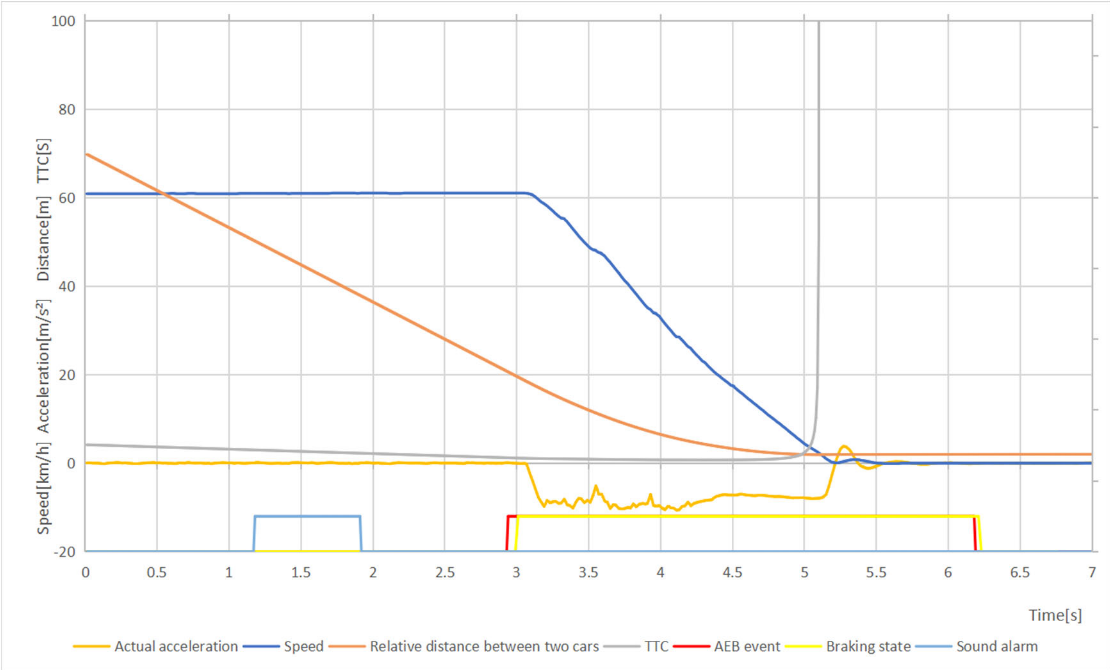

Figure 3. AEB Control Process(60km/h)

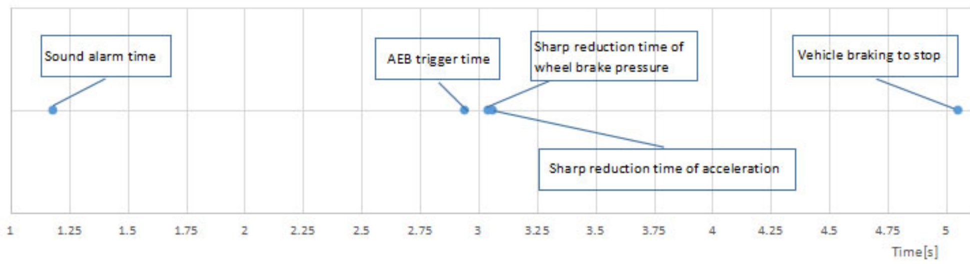

Figure 4. Critical Time Points(60km/h)

Figure 5. AEB Control Process(70km/h)

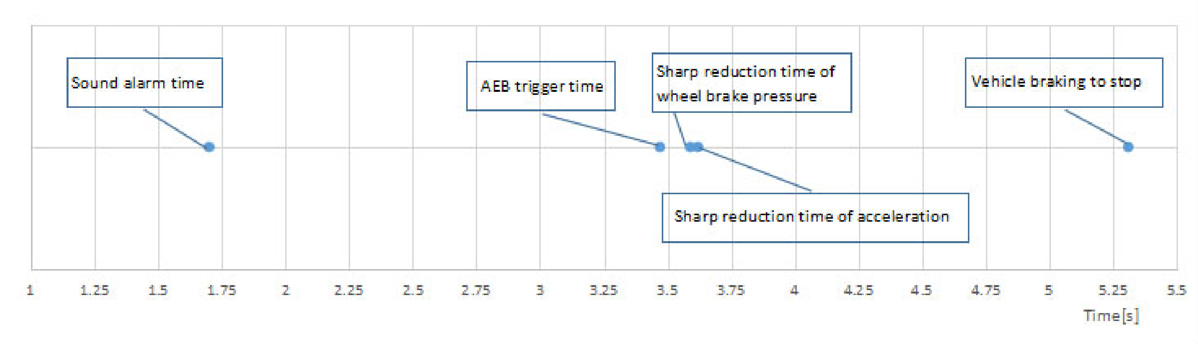

Figure 6. Critical Time Points(70km/h)

Through the analysis of AEB braking process at different speeds, we can comprehensively analyze the AEB braking effect and braking strategy of the test vehicle. The test results are helpful to promote the technical improvement of test vehicles and the benchmarking research of other vehicles. In the whole test process, AEB test system runs stably, can accurately obtain test data, and can fully meet the test requirements of AEB system.

4. CONCLUSION

Firstly, this paper introduces the overall architecture of AEB test system. Secondly, the reverse parsing method of CAN bus signal is introduced. Thirdly, the equipment installation and data fusion methods are described. Finally, the real vehicle test is carried out based on the built test system and the test scenarios designed above. The research on the control strategy of the AEB system not only provides a deep understanding of the vehicle braking mechanism, but also provides data references for the research of safer and more reliable AEB algorithms. The test results well verify the AEB test research method designed in this paper, provide a reference for other research institutions to study the AEB control strategy, and are of great significance to improve the benchmarking level of vehicle AEB control strategy research.And with the gradual deepening of autonomous driving technology research and the gradual expansion of autonomous driving applications, ADAS functions will surely receive more and more attention, which is also the focus and difficulty of future research.

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