Development trend analysis of combined driving assistance based on C-ICAP

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Abstract. With the development of intelligent connected vehicles, the assembly rate of combined driving assistance systems is increasing year by year. Based on the test and evaluation results of "China Intelligent-connected Car Assessment Programme, C-ICAP", this paper analyzes the performance and development trend of the combined driving assistance system in the two projects of Cut-out and Cut-in based on assessment of 29 vehicles in 2022 and 2023.

Keywords: Combined Driving Assistance, C-ICAP, Cut-out, Cut-in, Intelligent configuration

1. Introduction

With the rapid development of science and technology, the assembly rate of combined driving assistance system is increasing gradually. With the improvement of intelligent sensors, artificial intelligence and data processing capabilities, combined driving assistance systems are constantly evolving and improving, bringing safer, comfortable and convenient driving experience to drivers [1,2].

The combined driving assistance system provides strong support to the driver by sensing the surrounding environment, making real-time decisions and performing driving actions. From the original adaptive cruise control (ACC) to the more advanced pilot driving assistance (NOA), the system features and performance have evolved continuously.

Based on the data of "China Intelligent-connected Car Assessment Programme，C-ICAP" in 2022 and 2023, this paper analyzes the technological development trend of the combined driving assistance system. It can be found that with the improvement of intelligent configuration, the combined driving assistance system has been significantly improved in some dangerous scenarios in the past two years.

2. Introduction to C-ICAP

"China Intelligent-connected Car Assessment Programme，C-ICAP" is a assessment procedure for intelligent connected vehicles launched by China Automotive Technology and Research Center Co.,Ltd. Since 2018, China Automotive Technology and Research Center

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Co.,Ltd. began to conduct research on the assessment of ADAS, and has successively issued and implemented "China Intelligent-connected Car Assessment Programme, C-ICAP" to conduct a comprehensive assessment of ADAS. In the past two years, China Automotive Technology and Research Center Co.,Ltd. as an third-party evaluation agency, completed a total of 30 models of C-ICAP assessment, including 22 models completed in 2022 and 8 models completed in 2023. According to the type of energy, the number of tests and evaluations is shown in Table 1.

Table 1. Vehicle type distribution.

Energy type	2022	2023	Total
Electric Vehicle	9	6	15
Gas-powered Car	13	2	15
Total	22	8	30

3. Assessment scenario introduction

In order to study the development trend of combined driving assistance function, this paper selected two scenarios with high loss rate from the "China Intelligent-connected Car Assessment Programme, C-ICAP" for data analysis, respectively Cut-out and Cut-in.

3.1 Cut-out

3.1.1 Test Scenarios

As shown in Figure 1, the test road shall be a long straight road with at least two lanes, the middle lane line shall be a white dotted line, and the lane width shall be 3.75m. The VUT shall run in any lane, and there shall be the VT in front of the VUT.[3.4.5]

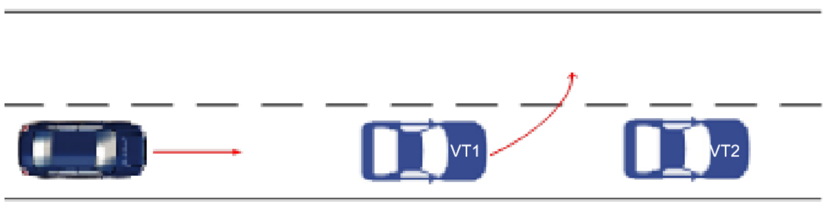

Figure 1. Schematic Diagram of Test Scenario for Cut-out.

3.1.2 Test Method

After the system is activated, the vehicle speed shall be set from low to high for test. The VT1 shall run along the middle of the lane, and the VUT shall follow the VT1 ahead with a relatively stable following distance. The VT1 shall cut out of the lane when approaching the VT2, and then run along the middle of the adjacent lane. During the process, the driver shall hold the steering wheel with both hands and shall not interfere with the normal operation of the system. The speed of VT, the distance between the VT1 and the VT2 when the VT1 cuts out of the lane, and the duration of cut-out process of the VT1 are shown in Table 2.[3.4.5]

Table 2. Test Parameters for Cut-out

Set speed of the VUT (km/h)	Speed of the VT1 (km/h)	Speed of the VT1 (km/h)	Distance between the VT1 and the VT2 (m)	Duration of cut-out operation of the VT (s)
50	40	0	25	2.2
70	60	0	37	2.2

3.1.3 Explanation on Scoring

1) If the VUT does not collide with the target and the maximum deceleration during braking operation does not exceed $5m/s^2$, then 100 points will be obtained;

2) If the VUT does not collide with the target and the maximum deceleration during braking operationexceeds$5m/s^2$, then 70 points will be obtained;

3) If the VUT collides with the target, then the score shall be calculated according to the Formula 1 below:

$$\text{Score} = 70 \times \frac{Vrel,test - Vrel,impact}{Vrel,test} \quad (1)$$

Where: Vrel,test: the relative speed of the VUT and the VT at the beginning of the test.

Vrel,impact: the relative speed of the VUT and the VT when they collide with each other, which shall be calculated by subtracting the longitudinal speed of the VT from the speed of the VUT at the time of collision[3.4].

3.2 Cut-out

3.2.1 Test Scenarios

As shown in Figure 2, the test road shall be a long straight road with at least two lanes, the middle lane line shall be a white dotted line, and the lane width shall be 3.75m. The VUT and VT shall run in their respective lanes. When the VUT approaches the VT, the VT shall cut into the lane where the VUT is located[3.4.5].

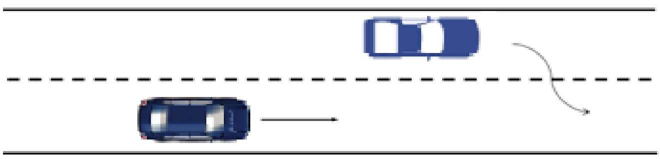

Figure 2. Schematic Diagram of Test Scenario for Cut-in

3.2.2 Test Method

After the system is activated, the vehicle speed shall be set from low to high for test. The VUT shall reach the expected speed before it is only 200m away from the VT, and shall run steadily in the lane. The VT shall run at a constant speed along the middle of the adjacent lane in the same direction, quickly cut into the lane where the VUT is located, and then run along the middle of the lane. During this process, the driver shall hold the steering wheel with both hands and shall not interfere with the normal operation of the system. The set speed of the VUT, the speed of the VT, the distance between the VT and the VUT when the VT cuts in the lane, and the duration of the cut-in operation of the VT are shown in Table 2-4[3.4.5].

Table 3. Test Parameters for Cut-in

Set speed of the VUT (km/h)	Speed of VT (km/h)	Time gap between front end and the rear end of VT (s)	Duration of cut-in operation (s)
40	20	1.5	2.2

3.2.3 Explanation on Scoring

1) If the VUT does not collide with the target, it can follow the target steadily, and the maximum deceleration during braking operation does not exceed 5m/s^2, then 100 points will be obtained;

2) If the VUT does not collide with the target, but it cannot follow the target steadily or the maximum deceleration during braking operation exceeds5m/s^2, then 70 points will be obtained

3) If the VUT collides with the target, then the score shall be calculated according to the Formula 2 below:

$$\text{Score} = 70 \times \frac{Vrel,test - Vrel,impact}{Vrel,test} \tag{2}$$

Where: Vrel,test: the relative speed of the VUT and the VT at the beginning of the test.

Vrel,impact: the relative speed of the VUT and the VT when they collide with each other, which shall be calculated by subtracting the longitudinal speed of the VT from the speed of the VUT at the time of collision[3.4.5].

3.2.4 Test equipment

In order to reduce the test risk, soft targets replacing actual M_1 passenger cars are selected during the test. According to the requirements of ISO19206, soft targets should have the attributes of real vehicles, including visual characteristics, radar reflection characteristics, point cloud characteristics, etc., the appearance of the soft target used in this paper is shown in Figure 3.

Figure 3. Soft Targets

In order to ensure the test accuracy, the equipment used in this test is mainly the inertial GPS navigation test system and synchronization controller, as shown in Figure 4 [6.7].

Figure 4. GPS Navigation Test System & Synchronization Controller

4. Assessment scenario introduction

Based on the C-ICAP technical procedures, this paper makes a statistical analysis of the data of the 2022 and 2023 assessment and models. From 2022 to 2023, China Automotive Technology and Research Center Co.,Ltd. selected a total of 30 models for assessment, of which only 1 model does not have a combined driving assistance function. The specific results and sensor configurations are shown in Table 4 and Table 5.

Table 4. Vehicle performance and sensor configuration statistics in 2022

Model number	Scoring average（%）			Sensor configuration			
	Low speed Cut-out	High speed Cut-out	Cut-in	Ultrasonic radar	Millimeter wave radar	Camera	Laser radar
Vehicle 1	0	6.7	21.6	8	3	5	0
Vehicle 2	70.0	44.4	70.0	12	5	7	0
Vehicle 3	100.0	70.0	70.0	12	5	13	1
Vehicle 4	70.0	60.0	70.0	12	2	7	0
Vehicle 5	100.0	56.5	100.0	8	1	5	0
Vehicle 6	100.0	100.0	70.0	4	0	6	0
Vehicle 7	0	0	70.0	0	1	1	0
Vehicle 8	100.0	60.0	100.0	3	0	6	0
Vehicle 9	70.0	53.8	70.0	0	1	1	1
Vehicle 10	100.0	70.0	13.3	12	5	7	0
Vehicle 11	70.0	0	70.0	12	5	6	0
Vehicle 12	43.1	0	0	4	1	6	0
Vehicle 13	0	0	0	0	0	1	0
Vehicle 14	100.0	70.0	100.0	12	6	13	3
Vehicle 15	70.0	40.8	70.0	8	2	1	0

Vehicle 16	70.0	54.0	100.0	8	3	5	0
Vehicle 17	70.0	51.0	70.0	6	3	8	0
Vehicle 18	70.0	64.7	70.0	8	3	5	0
Vehicle 19	0	0	0	12	1	5	0
Vehicle 20	0	0	0	12	1	1	0
Vehicle 21	70.0	34.7	28.6	4	3	6	0
Average	60.6	39.8	55.4	——			

Table 5. Vehicle performance and sensor configuration statistics in 2023

Model number	Scoring average（%）			Sensor configuration			
	Low speed Cut-out	High speed Cut-out	Cut-in	Ultrasonic radar	Millimeter wave radar	Camer a	Laser radar
Vehicle 1	100.0	70.0	100.0	12	1	11	1
Vehicle 2	100.0	70.0	100.0	12	6	13	3
Vehicle 3	70.0	11.3	70.0	8	3	2	0
Vehicle 4	100.0	70.0	14.8	12	4	4	0
Vehicle 5	100.0	70.0	70.0	12	5	13	1
Vehicle 6	70.0	8.3	6.0	12	3	5	1
Vehicle 7	100.0	70.0	70.0	12	5	13	1
Vehicle 8	70.0	70.0	70.0	12	0	2	0
Average	88.8	55.0	62.6	——			

The following conclusions can be summarized from Table 3：

1) Low laser radar assembly rate in 2022. Of the 21 vehicles tested in 2022, there are two vehicles with laser radar, accounting for less than 10%.

2) In the three cases mentioned, the overall performance needs to be improved. The specific performance is shown in Table 6.

Table 6. Vehicle performance statistics for 2022

Test scenario	Performance classification（%）			
	Collision avoidance and comfort	Collision avoidance and discomfort	Collision mitigation	non-function
Low speed Cut-out	28.6%	42.8%	4.8%	23.8%
High speed Cut-out	4.8%	14.3%	52.4%	28.6%
Cut-in	19.0%	47.6%	14.3%	19.0%

The following conclusions can be summarized from Table 4：

1) The laser radar assembly rate increased in 2023. Of the eight vehicles tested in 2023, six were equipped with laser radar, accounting for 75%.

2) Overall performance improved significantly in all three cases compared to 2022. The specific performance is shown in Table 7.

3) Although the sensor types of Vehicle 3 are relatively complete and the number is relatively large compared with Vehicle 5, Vehicle 6 and Vehicle 8, the average score of Vehicle 3 in the above three scenarios is lower than that of Vehicle 5, Vehicle 6 and vehicle 8.

Table 7. Vehicle performance statistics for 2023

Test scenario	Performance classification（%）			
	Collision avoidance and comfort	Collision avoidance and discomfort	Collision mitigation	non-function
Low speed Cut-out	62.5%	37.5%	0.0%	0.0%
High speed Cut-out	0.0%	75.0%	25.0%	0.0%
Cut-in	25.0%	50.0%	25.0%	0.0%

Figure 5 shows the average scores of the measured vehicle in the three scenarios of low speed cut out, high speed cut out, and cut-in, and the highest scores in the three scenarios. It can be found that the average score rate in 2023 is significantly better than that in 2022, and the level of some vehicles is significantly higher than the industry average.

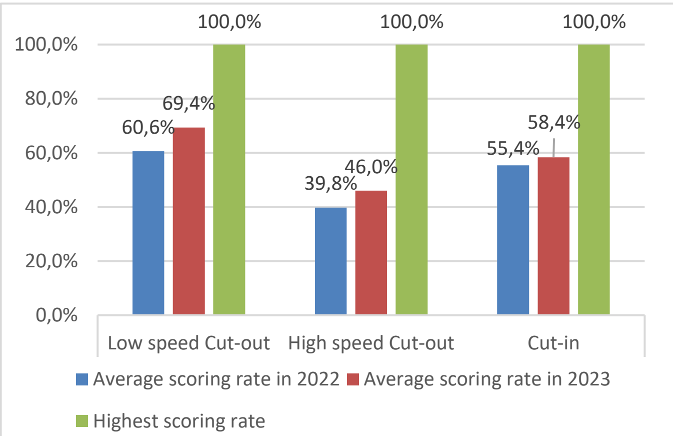

Figure 5. Scoring rate statistics

5. Conclusion

By analyzing the historical assessment data in 2022 and 2023, as well as the vehicle intelligent configuration, this paper finds the following conclusions:

Through the comparison of the data in 2022 and 2023, it can be found that: with the development of intelligent network technology, the combined driving assistance performance has been significantly improved in some extreme scenarios;

Through the comparison of the 2022 data, it can be found that the improvement of the combined driving assistance performance does not entirely depend on the hardware configuration. Under the condition of limited hardware resources, the system performance can be improved through software research and development;

As can be seen from Figure 3: the products of some enterprises in the industry perform better in extreme scenarios, which means that there is room for improvement in the performance of combined driving assistance systems. According to Table 3 and Table 4, it can be found that laser is of great significance in solving extreme scenarios.

In the process of analysis, this paper only selected the data of two types of scenarios: cut-out and cut-in, which can only prove that the performance of the combined driving assistance system has been improved in the above scenario, but in other dangerous scenarios (such as pedestrian crossing, motorcycle crossing, etc.), the performance of the combined driving assistance system still has a high room for improvement.

With the continuous progress of technology and the increasingly rich application scenarios, the driver assistance system will be more mature and intelligent, laying a solid foundation for the construction of intelligent transportation system and realizing the goal of transportation power. The government, enterprises and all sectors of society should work together to strengthen cooperation and innovation, and promote the popularization and development of intelligent connected vehicles[8.9].

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