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Study on the Test Scenarios of Level 2 Automated Vehicles*

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Abstract—**Testing in the closed field is one of the important means to verify the features and performance of automated vehicles. Due to the complicated and changeable traffic conditions, how to design the testing scenarios with relatively few number but significant value is a problem that deserves research. We analyze the features of the Level 2 automatic driving production models in the market. Based on the applicable scenarios of the main functions such as adaptive cruise control, active lane changing control and active lane keeping control for automated vehicles, the relative location among the ego-vehicle and its surrounding obstacle vehicles are permutated and combined to form a vehicle combination groups, and then for each vehicle combination, the directions of motion of the ego-vehicle and obstacle vehicles are arranged and combined to obtain a possible test scenarios groups. Based up the test scenario generated by the combination of the ego-vehicle and the obstacle vehicles, the valuable and simple primary test scenario is generated through the analysis of the scenario importance, and then an obstacle vehicle is added to form the new scenario of higher level. The valuable test scenarios with various levels are screened out by analyzing the new impacts of detection and response of the ego-vehicle exerted by the movement of the obstacle vehicles and evaluating the importance of the scenarios. Finally, total test scenario groups with test significance is obtained. The validity of this method is verified, and a test case for parameter design is given in the paper.**

I. INTRODUCTION

With the rapid development of artificial intelligence, automatic driving technology has become one of the most potential breakthrough technologies. It is estimated that the application of automated vehicles will reduce the pollutant emissions by 50% and the road traffic casualty rate will approach zero by 2050 [1]. The annual output value of automatic driving industry will increase 7 trillion dollars around [2]. Many countries in the world are actively deploying automated vehicle technology, but the progress and development of automatic driving technology requires a sound test and verification process.

Automated driving test methods are generally divided into four categories: simulation, dynamic driving simulator, controlled field test and field operational test (FOT) [3]. Simulation and dynamic driving simulator are usually carried out in the early stages of the research and development with virtual scenes and vehicles, which can quickly evaluate the performance of autonomous driving systems to ensure vehicle behavior safety. In the following stage of system development, it is necessary to conduct controlled tests and reproduce the typical traffic scenarios in the test site. This stage is a realistic and effective way to assess the performances of automated vehicles and user-related properties. FOT is the ultimate evaluation of automatic driving tests. However, the FOT will take high cost and long time, and it has a certain risk. Therefore, it is necessary to fully excavate the defects of the automated vehicle and improve the testing efficiency in the controlled field test in the early stage.

So far, testing standards of advanced driving assistance system (ADAS) such as EURO-NCAP (AEB, LSS, SAS, etc.), ISO 15622/17387/11270 (ACC, LCDAS and LKAS) and ECE (AEBS) have been set up. However, the Level 2 automated vehicle still lacks a perfect test evaluation procedure. Test scenario design is a key aspect for the test of automated vehicle. Earlier tests regulations of the ADAS were based on analysis of accident databases such as the 2015 edition of the General Estimates System (GES) database published by the NHTSA, which including thirteen categories of crash types [4]. Based on GES and other databases, Kusano divided the crash scenes into single-car crash and multi-car crash and sorted out totally 18 kinds of crash scenes [5]. China In-Depth Accident Study (CIDAS) is based on China accident database to extract typical accident scenarios such as near-crash scenarios related to pedestrian [6]. In recent years, Europe has conducted a number of large-scale test projects such as AdaptIVe to evaluate some autonomous driving functions of Level 2 and higher level from several aspects such as technical assessment, user-related assessment, traffic assessment and impact assessment (safety and environmental effects). And proposed three types of test scenarios including close-range scenarios, urban scenarios and motorway scenarios, which including 33 major scenarios and 36 alternative scenarios [7-8].

Some scholars have made some researches on the test scenario design methods of automated vehicles. Jinwei Zhou classified the test scenarios by a basic test case with only one influence factor, gradually increasing the number of factors and avoiding behaviors such as braking, accelerating, steering wheel to form complex test conditions [9]. Sebastian Siegl proposed a test model for the structure of an autonomous driving system, with the idea that one state changes to another through a series of incentives, then he sorted and optimized the process based on practical experience [10]. Ruben Schilling proposed to validate the function of automated vehicles by setting up different test scenarios with weather conditions (daytime and nighttime), road types, driving

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parameters (speed, etc.) [11]. Xiong Guangming summed up the static and dynamic factor library of road traffic environment for the quantitative evaluation of automated vehicles to form different levels of test scenarios [12]. Li Li proposed a test framework for synthesizing scenarios and functions, which describes the testing process through the semantic graphs [13].

In summary, the design of test scenarios of automated vehicles should consider the influences of many kinds of traffic factors comprehensively and select critical test scenarios according to the characteristics of the traffic accident scenarios.

II. TEST SCENARIO DESIGN

A. *Function Features Analysis of Existing Level 2 Production Automated Vehicles*

With the advancement of automated vehicle, the amounts of Level 2 production automated vehicles are gradually increasing, such as Autopilot of Tesla, Drive Pilot of Mercedes-Benz, Pilot Assist of Volvo, Super Cruise of Cadillac, BMW and so on. According to the SAE J3016 [14], the definition of Level 2 automated vehicles is that "the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human drivers manipulate all remaining aspects of the dynamic driving task". These Level 2 automated vehicles have the common basic functions which are adaptive cruise control (ACC) and lane keeping assist (LKA), adaptive cruise control and lane change assist (LCA) or steering assist. Besides, the Level 2 automatic driving functions of Mercedes-Benz and BMW include identifying the speed limit sign, as well as the automatic parking function. The Drive Pilot of Mercedes-Benz also incorporates the passive safety system for rear-end collision defense and automatic deceleration for traffic conditions such as curve, corners, intersections, roundabouts and tollbooths. BMW's automatic driving system has pedestrians warning, rear collision warning, front and rear cross-action warning function at the same time. In addition, the Tesla Automated driving system is able to pass the entrance and exit of the highway automatically. It is worth mentioning that the Level 2 automated vehicles of Mercedes-Benz, BMW, Volvo and Cadillac are also equipped with driver attention monitoring system to continuously detect whether the driver is involved in the driving task.

Based on the above features of the Level 2 automated vehicles, test scenarios of the Level 2 automatic driving system must not only evaluate the basic functions, but also evaluate some specific functions at the same time. The paper mainly focuses on the basic functions, the lateral and rear collision avoidance functions and the early-backward crossing behavior warning function of Level 2 automated vehicles.

B. *Traffic Conditions*

The real-world driving conditions of vehicles on the natural road are complex and various. In order to fully evaluate the performance of automated vehicles, different traffic environment must be considered in the test scenario design. Static environments include road type (urban, suburban, highway, mountain, parking lot, intersection, etc.), weather (rain, snow, light, etc.), traffic elements (traffic signs, etc.). Dynamic traffic environments include the movement status of surrounding vehicles or other traffic participants (pedestrians, cyclists and animals, etc.) such as the relative position (including the lane and the relative position), the relative traveling direction and the relative speed, traffic lights and so on.

In this paper, the function features of the Level 2 automated vehicles are considered to study the formation and screening of the test scenarios under the specified traffic conditions. The specified traffic conditions are straight, curved and ramp sections of urban road and highway, and the traffic participants are vehicles.

C. *The Formation and Screening of Test Scenarios*

Under certain traffic conditions, the possible relative positions and directions of motion of surrounding vehicles or other traffic participants to the ego-vehicle are the key factors for the design of test scenarios. A method is proposed to generate scenarios from simple to complex by analyzing the scenario importance. Specific steps are as follows:

First, according to the amounts of vehicles around the ego-vehicle, it can combine possible relative positions among them to form possible vehicle groups. Taking a three-lane scenario as an example, see Fig.1. The SV is the Ego-Vehicle and C1-C8 represent possible location areas of surrounding vehicles (also referred to be obstacle vehicles), where the area between L1 and L2 represents the blind zone of the ego-vehicle. When there is no obstacle vehicle around the ego-vehicle, the ego-vehicle is in the free driving conditions; when there is one obstacle vehicle around the ego-vehicle, the location of this obstacle vehicle has 8 ($C_8^1 = 8$) possibilities. So, there is 8 kinds of position combinations between the ego-vehicle and any one obstacle vehicle; when there are two obstacle vehicles around the ego-vehicle, the relative position combinations among the ego-vehicle and any two obstacle vehicles have 28 ($C_8^2 = 28$)possibilities. By analogy, by analogy, the permutation and combinations of the relative positions among the ego-vehicle and any N number of obstacle vehicles around can be obtained.

Secondly, for each combination of relative position formed by ego-vehicle and the surrounding obstacle vehicles, according to the function of Level 2 automated vehicle (do not consider the reversing, and functions not included in L2 such as left/right U turn and retrograde), the ego-vehicle has five

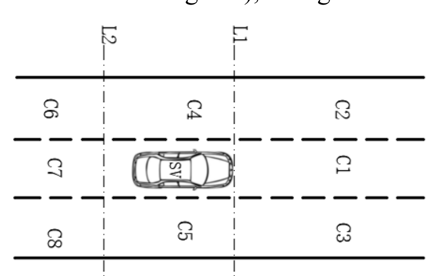

Fig. 1 Relative positions of surrounding vehicles.

possible driving directions such as going straight, left/right lane change, and left/right lateral moving, see Fig.2a. The possible driving directions of surrounding vehicles has 9 possibilities such as going straight, left/right lane change, left/right lateral moving, and left/right U turn, reversing and stillness, see Fig.2b. The direction of movement for the ego-vehicle and any one obstacle vehicle is combined to form the scenarios, and a low-level simple scenario groups is obtained by eliminating the worthless scenario with the screening method. On this basis, the relative positions and driving directions of the ego-vehicle and any two obstacle vehicles are combined to form a new valuable higher-level scenarios groups by the scenario screening method. By analogy, finally a high-level test scenario groups are formed by the combining ego-vehicle with any N obstacle vehicles. The test scenarios groups of all levels are combined to constitute the valuable normal driving scenarios groups and pre-crash condition groups.

The scenario importance is used to judge the test value of the designed test scenarios. It is assumed here that the automatic system-related hardware and software are all fault-free (including environment recognition, software, positioning, and maps are error-free), and the road users are only vehicles around the automated vehicle. In this case the scenario importance is defined as four levels.

- If the change of the orientation and movement of the obstacle vehicle may cause the automated vehicle to be unable to perform the expected behavior due to a possible collision with the obstacle vehicle in a scenario, the degree of scenario importance of this condition is level A.
- If the disturbance of the position and movement of the obstacle vehicle would enable the automated vehicle to perform the expected automated driving behavior, but making the longitudinal and lateral speeds of the automated vehicle have new changes in a scenario, the degree of scenario importance is level B.
- If the disturbance of the position and movement of the obstacle vehicle would enable the automated vehicle to perform the expected automated driving behavior, but making the longitudinal or lateral speeds of the automated vehicle have new changes in a scenario, the degree of scenario importance is level C.
- If the disturbance of the position and movement of the obstacle vehicle would enable the automated vehicle to perform the expected automated driving behavior, but making no or little new influence on the longitudinal and lateral speeds of the automated, the degree of scenario importance is level D.

In order to obtain the scenarios with test significance, the following principles is established to screen out the valuable test conditions: scenarios with an importance degree of D have no test significance and will be excluded. if the impact of detection and response of ego-vehicle interfered by the movement of multiple obstacle vehicles in the higher-level scenarios is same as the that of lower one level scenarios with one less obstacle vehicle, those higher scenarios also are no longer considered.

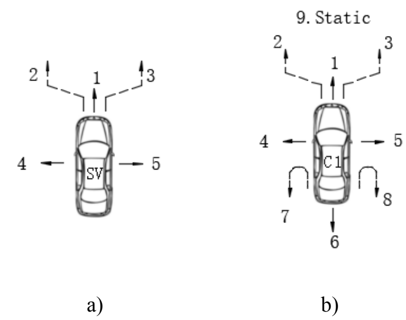

Fig. 2 Driving directions of SV and surrounding vehicle.

Finally, parameter for test scenarios is designed. According to the driver behavior characteristics, traffic rules, typical driving parameters such as speed, acceleration, deceleration, lateral speed, lateral acceleration in urban, suburban and highway, and vehicle crash database from China and abroad and so on, the driving parameters of the ego-vehicle and obstacle vehicles in the normal and pre-crash conditions can be formed as a test case, and the validity and safety is verified through simulation.

III. Examples of Test Conditions

This section provides some examples of how to design the test scenarios described in section II. The following contents will be divided into two parts to introduce, which are the scenario design with one obstacle vehicle and two obstacle vehicles at the surrounding of ego-vehicle on respectively.

A. There is one obstacle vehicle around the ego-vehicle

When there is one obstacle vehicle around the ego vehicle, the obstacle vehicle in the C1 range is taken as an example for analysis. The ego-vehicle has five possible driving directions including going straight, left/right lane change and left/right lateral moving. The possible driving directions of the obstacle vehicles in C1 area has 9 possibilities such as going straight, left/right lane change, left/right lateral moving, and left/right U turn, reversing and stillness. For the ego-vehicle of Level 2 automated vehicle cannot actively avoid the oncoming vehicle, the reversing and retrograde of the surrounding vehicles can be excluded. So, the obstacle vehicle around the ego-vehicle of Level 2 automated vehicle has 8 possible movements. The ego-vehicle and the obstacle vehicle can be arranged and combined to form 40 ($C_5^1 \times C_8^1 = 40$) possible test scenarios.

The situation of ego-vehicle going straight (ACC mode): it combines with eight motion directions of the obstacle vehicle into 8 scenarios. Among these scenarios, the three possible driving directions of the obstacle vehicles (left lane change, left U turn and left lateral moving motion) have almost the same influence on longitudinal movement speed and vehicle target recognition of the ego-vehicle. And the left lateral moving of the obstacle vehicles has less effect on movement of ego-vehicle than the others, so the left lane change condition of the obstacle vehicles is reserved to test and exclude the 2 conditions of left U turn and left lateral moving.

Likewise, the right U turn and right lateral moving conditions can be excluded. Therefore, the reserved 4 scenarios are formed by the combination of the straight movement of the ego-vehicle and 4 movements (going straight, left/right lane change and stillness) of the obstacle vehicles. The importance grade of four scenarios are all level C.

The situation of ego-vehicle taking the left lane change (ACC plus LCA mode): it combines with eight motion directions of the obstacle vehicle into 8 scenarios. Among these scenarios, the right lane change, right lateral moving and right U turn of the obstacle vehicles have little influence on the ego-vehicle's movement, and the scenario importance grade is D. So, these 3 scenarios are excluded. Besides, the left U turn of the obstacle vehicle will affect the ego-vehicle to finish automated left lane change movement, for Level 2 automated vehicle cannot actively avoid the coming vehicle, So, the condition of the left U turn of the obstacle vehicle can be excluded. The left lane change and left lateral moving of the obstacle vehicles have similar influence on the ego-vehicle, and the former affects relatively much more. So, the left lateral moving condition is excluded. The reserved 3 conditions are the left lane change movement of the ego-vehicle combining with the left lane change, going straight and stillness of the obstacle vehicle and the scenario importance grade is level B, B and C respectively.

The situation that the ego-vehicle is taking the right lane change is similar to the left lane change scenarios and 5 similar scenarios are excluded. So, 3 scenarios are left, combined by the right lane change movement of the ego-vehicle with the right lane change, going straight and stillness of the obstacle vehicles. The scenario importance grade is level B, C and C respectively.

The situation of the ego-vehicle taking left lateral moving (ACC plus LKA mode): It is assumed that both the ego-vehicle and the obstacle vehicle are located on the right side of the road centerline in the beginning of test. The left lateral moving of the ego-vehicle and the 8 motion directions of the obstacle vehicle are combined into 8 scenarios. Among them, the right lane change, right lateral moving or right U turn of the obstacle vehicles has little influence on the ego-vehicle. The scenario importance is all D and can be excluded. The left lane change and left U turn of the obstacle vehicles almost have the same influence on the ego-vehicle, and just reserve the left lane change condition and exclude the left U turn condition. So, the reserved 4 conditions are the left lane change movement of the ego-vehicle combining with the left lane change, left lateral moving, going straight and stillness of the obstacle vehicles and the scenario importance grade is level B, B, C, and C respectively.

The situation that the ego-vehicle is taking right lateral moving is similar and 4 conditions can be excluded. And the 4 scenarios are left, which are the right lane change movement of the ego-vehicle combining with the right lane change, right lateral moving, going straight and stationary of the obstacle vehicles.

In summary, the situation that one obstacle vehicle is just in the front of the ego-vehicle and in C1 area can form 18 testable scenarios, and part scenarios are shown in Fig.3.

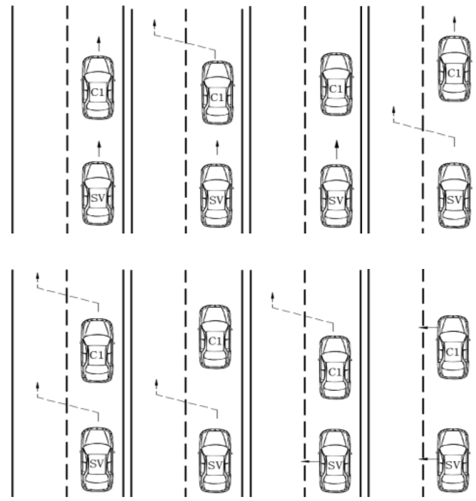

Fig. 3 Part of test scenarios with one obstacle vehicle.

B. There are two obstacle vehicles around the ego-vehicle

On the base of the determined simple test scenario groups formed by ego-vehicle and one obstacle vehicle, the test scenarios combined by the ego-vehicle and surrounding any two obstacle vehicles can be designed. Here, we take the two obstacle vehicles respectively in the C1 and C2 area as an example to introduce the process of scenario design.

First of all, it needs to determine the relative longitudinal distance among the obstacle vehicle in C2 and C1 area and ego-vehicle, mainly considering whether the obstacle vehicles would affect the movement of ego-vehicle. We choose the situation that the longitudinal position of obstacle vehicle in C2 area is between the ego-vehicle and the obstacle vehicle in C1 area and make sure that the obstacle vehicle in C2 area can cut in front of the ego-vehicle. In the same way, when two obstacle vehicles in C3 and C1 area, it also needs to consider the same symmetrical scenario.

The obstacle vehicle in C2 area is located in the left adjacent lane of the ego-vehicle and its three possible movements including left lane change, left lateral moving and left U turn have no effect on the movement of the ego-vehicle. Besides, the other three movements including stillness, reversing and right U turn would not make the ego-vehicle to perform left lane change. So, there are only 3 driving directions left, which are going straight, right lane change and right lateral movement. When the obstacle vehicle in C1 area is retrograde/reversing or turning to the left, it cannot keep the ego-vehicle staying in the automatic driving mode. When the C1 vehicle is stillness, the scenarios combined by the vehicles in C2 area cannot conduct lane change to the right. Besides, those movements including right lateral moving, right lane change and right U turn of vehicle in C1 area can be eliminated, which considered by the combined scenario of the ego-vehicle and the obstacle vehicles in the range of C1 and C3. So, the obstacle vehicle in C1 area has only 3 directions of movement (going straight, left lane change, and left lateral moving) affecting the L2 automated vehicle; the ego-vehicle has 3 directions of movement (going straight, left lane change, and left lateral moving), seen in Fig.4. Therefore, combining the possible driving directions of the obstacle vehicle in the range of C1 and C2 and the ego-vehicle can form 27 ($C_3^1 \times C_3^1 \times C_3^1 = 27$) possible test scenarios.

The situation of the ego-vehicle going straight (ACC or AEB mode): It can be combined with the possible movements of two obstacle vehicles to form 9 test scenarios. Compared to the simple test scenarios which are combined by ego-vehicle with one obstacle vehicle in the area C1 or C2, there are only three scenarios that the obstacle vehicles in the area C1 and C2 can exert new impacts on the detection and response of ego-vehicle. When the obstacle vehicle in area C2 taking the right lane change and cutting in front of the ego-vehicle and performing together with the obstacle vehicle in area C1, it may cause the ego-vehicle fail to maintain the ACC mode and request manual takeover. Besides, the left lane change and left lateral moving of the obstacle vehicle in area C1 have the similar effect on the ego-vehicle and the former has slightly larger effect than the latter. So only the two scenarios are selected, which is combined by the left lane change and going straight of the obstacle vehicle in area C1 with the right lane change of the obstacle vehicle in area C2. In other words, two valuable scenarios are selected in the condition of ego-vehicle going straight. The importance of these scenarios is all level A, shown in Fig.5.

The situation of ego-vehicle taking left lane change (LCA mode): It can be combined with the possible driving directions of two obstacle vehicles into 9 scenarios. Compared to the simple test scenarios which are combined by ego-vehicle with one obstacle vehicle in the area C1 or C2, there are three scenarios that the obstacle vehicles in the area C1 and C2 can exert new impacts on the detection and response of the ego-vehicle. The three scenarios are formed by the left lane change of the obstacle vehicle in area C1 combined with possible going straight, changing to the right lane or taking right lateral moving for obstacle vehicle in area C2. The importance of these scenarios is all level A, shown in Fig. 5.

The situation of ego-vehicle taking left lateral moving (ACC and LKA mode): It can be combined with the possible driving directions of two obstacle vehicles into 9 scenarios. Assuming that both the ego-vehicle and the obstacle vehicle in C1 area are located in the right side of the center line of the road at the beginning of the test. Compared to the simple test scenarios which are combined with ego-vehicle and one obstacle vehicle in the C1 or C2 area, there are only one scenario that the obstacle vehicles in the C1 and C2 area can exert new impacts on the detection and response of the ego-vehicle: the obstacle vehicle in C2 area is taking lane change to right while the obstacle vehicle in C1 area changing to left. The importance of the scenario is level A, shown in Fig.5.

To sum up, six new valuable test scenarios are generated in the combination of ego-vehicle and the two obstacle vehicles in C1 and C2 areas. And this method can also be used to select new test scenarios when these two obstacle vehicles are in other areas. When there are more than two obstacle vehicles around the ego-vehicle, the forming and screening of the test scenarios can be analogy to design by this kind of method.

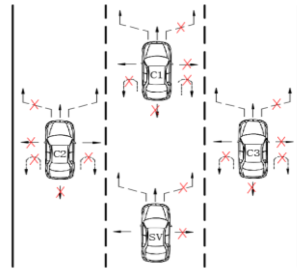

Fig. 4 Driving directions of SV and obstacle vehicles in C1 and C2 area.

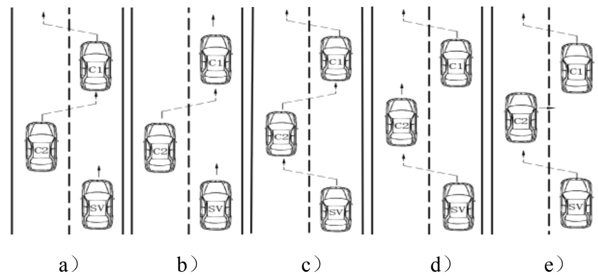

Fig. 5 Driving directions of SV and obstacle vehicles in C1 and C2 area.

IV. PARAMETERS DESIGN OF TEST SCENARIOS

Taking a curve scenario as example to design parameters, the scenario consists of the ego-vehicle and two obstacle vehicles respectively in C1 and C2 area. The scenario is used to test the curve-following performance and multi-target identification performance of the automated vehicle in the curve road. Taking the right turn as an example, the position of the ego-vehicle and the two obstacle vehicles are distributed as shown in Fig.6. The scenario is described as follows: On the curved road, there are an obstacle vehicle at area C1 in front of the own lane and an obstacle vehicle in area C2 of the adjacent lane respectively. They enter the curve at the same initial position and initial speed, and then the obstacle vehicle C2 decelerate to a certain speed. Until the ego-vehicle passes the curve, test is over.

The radius of the curve in this scenario refers to the classification value in the lane keeping system defined in ISO 11270, which are 125m, 250m and 500m respectively. Taking into account the highway radius of the curve, adding the curve radius of 1000m situation. The initial speed of obstacle vehicle C1 and C2 are respectively 50 km/h and 70 km/h for urban roads and 90 km/h for highway according to typical curve speeds of urban roads and highway. The deceleration of obstacle vehicle C2 is set at -1m/s2, and decelerating 20km/h. The follow-up time span of ego-vehicle respectively is set to the largest and the smallest case. Take the curve radius of

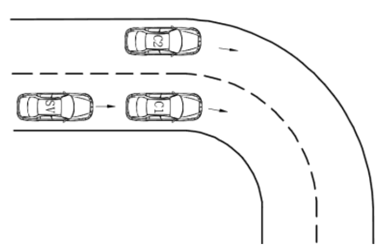

Fig. 6 Curve scenario illustration

TABLE I. PARAMETERS OF CURVE SCENARIO

No.	1	2
Road Type	Urban Curve with radius of 125/250/300m	
Set Speed of SV (km/h)	60	
Initial Time Interval	Max	Min
Initial Speed of C1 and C2 (km/h)	50	
Deceleration of C2 (m/s^2)	-1	
Speed of C2 after deceleration (km/h)	30	

500m in urban road condition and the 50km/h initial speed of the obstacle vehicle as example, shown in Table 1.

V. COVERAGE ANALYSIS OF TEST SCENARIOS

In order to demonstrate the feasibility of proposed method, we compare the designed test scenarios with test regulations of the Level 1 automated vehicles, the relevant traffic accidents database, the classification of test conditions defined by some projects, shown in Table 1. The number of included scenarios is the conditions included in the definition of reference resource. The irrelevant conditions refer to the traffic scenarios those are not within the definition of Level 2 automated driving system functions, such as intersections, roundabouts, highway entrances and exits, and scenarios related to system faults, activation and failures.

According to the statistical results, the proposed method in this paper has basically covered the driving conditions of vehicles except the fault condition and human-machine interaction within the scope of the definition of Level 2 automated vehicle, which proves the feasibility of this method preliminarily. Among them, the four excluded scenarios not considered in comparison with Waymo are as follows: blurring line of straight and curve road, slippery road, closing to the parking vehicle. One scenario not considered in ADaptIVe is the condition in which the front car is stillness in the lateral direction. The scenarios not considered in the GES collision conditions are the lateral collision conditions when traveling in the same direction. Since the test conditions in Waymo are for the Level 4 automated driving system and the functions tested in the ADaptIVe project included the Level 2 and higher level automated vehicle, so more consideration is given to the specific traffic scenarios. This paper is mainly aimed at the test scenarios design of filed test for the Level 2 automated vehicle with considering that the driver must participate in the driving task as well.

TABLE II. PARAMETERS OF CURVE SCENARIO

Resource	TN	IN	EN	IRN	CR
EURO-NCAP（AEB）	5	2	3	3	100%
ISO（ACC）	3	2	1	1	100%
NHTSA	28	5	23	23	100%
Waymo	46	22	24	20	84.6%
ADaptIVe	69	18	51	50	94.7%
GES 2015	35	17	18	17	94.4%

TN-Total scenario number
IN-Included scenario number
EN-Excluded scenario number
IRN-Irrelevant scenario number
CR-Coverage rate

VI. CONCLUSION

According to the need of filed test for the Level 2 automated vehicles and considering the features of the Level 2 automated vehicle functions, a basic test scenario groups is built by the permutation and combination of the relative position and movement directions among the ego-vehicle and the surrounding obstacle vehicles. A method is proposed to design from the preliminary test scenarios and generate more advanced complex scenarios by increasing the amount of obstacle vehicles gradually. The scenario importance and scene screening principles have been determined. Through the screening the valuable test scenario groups with different levels and functions is formed, and the number of scenarios is effectively reduced. The designed scenarios can be applied to simulation test by defining the parameters such as vehicle position, speed, acceleration and deceleration, lateral speed and lateral acceleration and so on with the fuzzy parameterized design method. The method can also be applied to the design of test scenario for Level 3 automated vehicle in traffic conditions such as intersections, roundabouts, highway entrances and exits. We will optimize the vehicle position and motion parameters through simulation and field test to form more effective test scenarios in the future.

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