Automotive Parking Assistant Testing Scene analysis and evaluation research

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Abstract. Since the existing automatic parking testing procedure scene is way too simple and idealized, it’s necessary to explore a set of effective verification procedure for the complex scene of Automatic Parking Assistant, which can evaluate the overall performance of the automatic parking function of different vehicles comprehensively, objectively and accurately. In the actual vehicle parking process, there are a lot of harsh and complex scenes which cannot be covered by the current verification system. This paper aims to build a set of effective verification system for the complex scene of automatic parking based on Artificial Intelligence technology. It can comprehensively, objectively and accurately evaluate the comprehensive performance of the automatic parking function of different vehicles.

1. Introduction

With the development of Internet, artificial intelligence and other advanced science and technology, the traditional automobile industry is experiencing the transformation to intelligence and connected vehicles, which can improve traffic efficiency and solve problems such as energy shortage, environmental pollution and traffic congestion. Therefore, test and evaluation requirements for key technologies have to be gradually introduced. On April 12, 2018, as Chinese ministries and committees jointly released the "ICVs Road Test Procedure (Trial)", numbers of authorized automobile related third-party testing institutions start testing and verifying business which focus on 14 different automatic driving functions. During testing and verifying business, lots of problems were found such as, test areas are seriously homogeneous, test procedure is mainly focusing on research and development phase of the field of conventional test roads, test procedure for ICVs under extreme working conditions, indoor complex meteorological conditions is lacked, which greatly limit the widespread application of ICVs. "ICVs Road Test Procedure (Trial)" is a basic test project for ICVs applying for road test of autonomous driving function, with the bottom line of ensuring the safety of autonomous driving test. Thus the most basic road type, the most common traffic signs and the most common vehicle driving state are selected in each automatic driving function test scene. Factors such as special road sections and weather are not taken into consideration. However, the working conditions in the actual test process of ICVs should be very complex, which means only strict and comprehensive test procedures can ensure the safety of the actual use and promotion of ICVs.

2. Automotive Parking Assistant (APA) route profile

APA can measure the distance and Angle between the car body and the surrounding environment through the sensors installed around the vehicle, collect sensor data and calculate the control strategy, then automatically adjust the steering wheel, brake pedal, throttle and so on to achieve parking automatically. According to the technical level, APA can be divided into semi-automatic parking, automatic parking, autonomous valet parking, etc. Automatic parking system is usually composed of
environment awareness system, central control system and execution system. At the present stage, the mature automatic parking technology framework of each OEMs is shown in Figure 1. However, in the next few years, the automatic parking technology will face a major technological upgrade. Due to the significant improvement in the performance of sensors, especially visual sensors in recent years, the performance of parking space detection will be greatly improved. In addition, the controller computing power of path planning is also greatly improved; The accuracy and responsiveness of the actuators have been greatly improved as well. Therefore the evaluation system we need should cover the development of automatic parking technology and the improvement of customer demand.

Figure 1. Automotive Parking Technology Framework

3. Establishing the automatic parking scene database.

Automatic parking scenes are very important part for the automatic driving test system. The diversity, coverage and typicality of test scenes can affect the accuracy of test results, which ensure the safety and quality of the automatic driving. Scenes are comprehensive reflection of the environment and driving behavior in a certain time and space, which describe the external states such as roads, traffic facilities, meteorological conditions, traffic participants, as well as the driving tasks and states of self-propelled vehicles. From the perspective of scene architecture, there are different driving occasions, such as expressways, rural roads, urban conditions, airports, docks, closed parks, etc. In this case, how to drive, driving task, driving speed, driving mode and so on together constitute the three-dimensional architecture of the whole automatic driving scene.

Based on the functional requirements, first of all, it’s needed to confirm the main influence factors, then to split out the impact factors, to differentiate impact factor according to the extreme extent, to select factors with complex limit degree combine to form the limit scenes database of automatic parking test. And then, according to the frequency of the limiting factors in the working condition of parking, select a certain number of specific test scenes.

| Main Factors | Impact Factors | Main Factors | Impact Factors | Main Factors | Impact Factors |
|--------------|----------------|--------------|----------------|--------------|----------------|
|              |                |              |                |              |                |
| ENVIRONMENTAL CONDITIONS (17) |                |              |                |              |                |
| Weather      |                |              |                |              |                |
| Rain         |                |              |                |              |                |
| Snow         |                |              |                |              |                |
| Temperature |                |              |                |              |                |
| VEHICLE TYPES (4) |              |              |                |              |                |
| A-class Car  |                |              |                |              |                |
| B-class Car  |                |              |                |              |                |
| C-class Car  |                |              |                |              |                |
| D-class Car  |                |              |                |              |                |

Figure 2. Automatic Parking Scene Database
The chosen scene cannot cover the evaluation of all scenes and working conditions, but focuses on the evaluation index of extreme working conditions and harsh scenes, cannot cover the evaluation of all scenes and working conditions. Taking Beijing, Shanghai, Guangzhou and Chongqing as the pilot cities, parking space information is collected from the dimensions of parking space type (parallel and vertical), parking space pavement material, road surface shape characteristics, surrounding obstacle type, surrounding environment, natural conditions, etc., so that a scene database that covers 70% of customers would be established.

In the process of collecting parking space information, laser radar and UWB positioning system are used to scan the parking environment through radar point cloud, extract features, and label parking space information. UWB positioning technology is a high-precision indoor positioning technology, which can carry out centimeter-level trajectory tracking, and can extract the shape and trajectory characteristics of parking spaces.

4. Establishing automatic parking scene index system
To provide the basis for the establishment of evaluation system, scientific and effective customer questionnaires were designed, which can explain the parking operations to market users by data mining. Meanwhile by the results of questionnaire, the unbiased and symmetrical scoring system of subjective evaluation tools can be developed, in turn, through the setting of parking indicators, the basis for the establishment of evaluation system will be provided.
1. Gender:
   □ Male
   □ Female

2. Age:
   16-20
   21-25
   26-30
   31-35
   Above 35

3. Do you know about driverless cars:
   A. Understand
   B. Heard of it but do not understand
   C. Never heard of it

4. Your attitude towards driverless cars:
   A. Support
   B. Do not support
   C. Doesn’t matter

5. How many years do you think it will take for driverless car technology to mature?
   A. In 10 years
   B. 10-20 years
   C. 20-40 years
   D. No end in sight

6. What are the current factors influencing your purchase of a driverless car?
   A. Cost are
   B. Technology not mature
   C. Inconveniente
   D. Other

7. Will you choose to buy a driverless car if the the technology is mature?
   A. Definitely
   B. Negatively
   C. Not sure

8. Which feature of a driverless car do you look forward to most?
   A. Lane keeping assistance system (LKAS)
   B. Automatic Parking Assistant (APA)
   C. Automatic emergency brake (AEB)
   D. Detecting people and objects around a vehicle
   E. Upgrade the infotainment system

Figure 5. Performance Index Questionnaire

Figure 6. The Analysis Model
People’s Republic of China Industry standards for public safety GA/T 850-2009 stipulate, that the size of urban road parking location should be 6 meters long, 2.5 meters wide, which cannot provide enough space to park into the parking location with obstacles at front or rear for vehicles with a length greater than 4.5 meters. Meanwhile, 93% respondents said that the automatic parking is needed, since that parallel parking is more difficult than vertical parking or diagonal parking.

In addition, respondents also believe that such problems as too narrow parking space, parking blind areas, long time parking significantly troubles them. The evaluation dimension was established through statistical analysis of respondents’ feedback questions. Thus The evaluation dimension was established through statistical analysis of respondents’ feedback.

Meanwhile, the parking conditions of different scenes are classified according to the external environment, and the harsh factors of the parking scenes are developed and calculated. The parking Spaces with harsh factors above 7 points are included in the evaluation system, and the screened scenes will be included in the test procedure and taken as the parking conditions.

Figure 7. Parking Scene Classification

5. The Construction of APA Performance Evaluation Method

After the self-parking test scenario is determined, the performance of the vehicle will be evaluated. The evaluation of automatic parking performance mainly includes two aspects: perception system evaluation and control system evaluation. The evaluation of the perception system is divided into two aspects: parking space perception and obstacle perception. The evaluation will be conducted from six aspects: perception time delay, perception recognition rate, parking space misperception, perceived HM ease of use, stationary obstacle perception and moving obstacle perception. The control system of safety evaluation can be divided into parking function control, parking, parking efficiency, parking comfort four aspects, including the number of parking suspension, parking success rate, pilot comfortable feeling, the minimum safety distance, operating frequency, parking duration, accelerate comfort, comfort, reducer, yawing comfort, etc.

According to the certain index above, a set of grading standards was set, divided into five levels, No Phenomenon, A Little Feeling, Feel But Don't Mind (standard), A Little Mind, Mind, which respectively correspond 2 points, 1 points, 0 points, -1 points, -2 points. Among above, Feel But Don't Mind is evaluating criteria, which is determined based on the level of the mass-produced car. The other levels are above or below the average. In different test scenarios, the performance of the automatic parking is evaluated, and the ultimate performance evaluation results of the automatic parking under the ultimate conditions are formed.
6. Conclusion
Above all, the main factors affecting the function of automatic parking are decomposed, and the degree of single factor is divided. The limit scenes of each factor are determined according to the threshold of different factors, the limit scenes library based on users is established according to the main factors that users are concerned about as well. Using the mainstream vehicles with APA on the market the automatic parking function of the vehicles was tested and evaluated from the perception system and control system, according to the defined limit scene database, and therefore, the comprehensive evaluation results are formed.

References
[1] Aljaafreh, A., Khalel, M., Al-Fraheed, I., Almarahleh, K., Al-Shwaabkeh, R., Al-Etawi, S., &Shaqareen, W. (2011). Vehicular data acquisition system for fleet management automation. 2011 IEEE International Conference on Vehicular Electronics and Safety, (pp. 130-133).
[2] Barbera, T., Horst, J., Schlenoff, C., & Aha, D. (2004). Task Analysis of Autonomous On-road Driving. Proceedings of SPIE Mobile Robots 2004 (pp. 61-72). Bellingham, WA: SPIE.
[3] Brewer, J., & Najm, W. (2015). Functional Safety Analysis of Automated Vehicle Lane Centering Control Systems. Automated Vehicles Symposium. San Fransisco, CA.
[4] K.Jiang, L.D. Seneviratne, A sensor guided autonomous parking system for nonholonomic mobile robots[A], Proceedings of the IEEE International Conference on Robotics and Automation[C], Detroit, Michigan, 1999.311-316 vol.1.
[5] Yanan Zhao, Emmanuel G., Collins Jr., Robust automatic parallel parking in tight spaces via fuzzy logic[J], Robotics and Autonomous Systems,2005.,51: 111-127.