

Study on influence factors of Intelligent Connected Vehicle (ICV) performance under Complex Weather Conditions

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Abstract—At the moment, ICV performance test method doesn't exist yet under the complex weather conditions, the revolution of ICV is greatly limited. By studying the weather environment that influence ICV, the meteorological indicators which influence ICV performance will be acquired. Then by analyzing the main complex meteorological factors, their scene characteristics and main control indexes are given. It provides a basis for the construction of the complex weather scene and the research of the test method of ICV under the complex weather condition.

1 INTRODUCTION

With the development of advanced technology, the automobile industry is becoming more and more artificial intelligence. The development of ICV can upgrade traffic efficiency and ease the strain of the environmental pollution, energy shortage and traffic congestion. On April 12, 2018, the Ministry of Industry and Information Technology of the People's Republic of China, the Ministry of Public Security and the Ministry of Transport of the People's Republic of China jointly released the test and Management Code for ICV road testing. The management specification claimed that test vehicles shall be fully tested in specific closed areas and verified its 14 self-driving functions by the third-party testing institution, then the self-driving road test application can be permitted. However, the test field demonstration area is very homogeneous, and the test mostly focuses on the routine road test. There is no standard test method and flow for ICV performance under the complex weather conditions, which has greatly limited to the promotion and application of ICV [1].

For this reason, studying the performance test of ICV has a great immediate and far-reaching significance under the complex weather conditions.

1.1. Accelerating the development of ICV testing technique

As the special situation, complex weather conditions rarely encountered in the open road or closed road test, which is particularly significant for the security of ICV. By analyzing ICV performance under the complex weather conditions, it is helpful to compare the industry data and build the database, then it promotes the development of ICV testing technique.

1.2. To meet the needs of enterprises for reliability assessment of ICV

Host factories and component suppliers are paying more and more attention to the relevant tests of ICV. However, at present, the test is mostly focused on the road field test in the research and development stage, there is no reliability test for ICV under the complicated weather conditions, which set limit ICV to put to use.

1.3. Supporting the establishment of ICV test standard

Through the research process and test results, the important performance indexes of the test are extracted, and then the vehicle performance under different complicated weather conditions is summarized, it provides the technical basis for the regulations and the industrial policies of China's automobile industry.

2 ANALYSIS OF THE INFLUENCE OF COMPLEX WEATHER CONDITIONS ON INTELLIGENT NETWORKED VEHICLE SENSORS

Perception module of ICV depends mainly on laser radar, vehicle camera, GPS and so on [2]. The perception module is greatly influenced by the complex weather conditions, which will directly influence ICV performance. For this reason, the performance of each perception module should be analyzed in the special equipment, then the crucial factors that affect the ICV performance can be acquired through the special equipment which developed by ourself. The special

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equipment is environmental chamber, which is shown in figure 1.

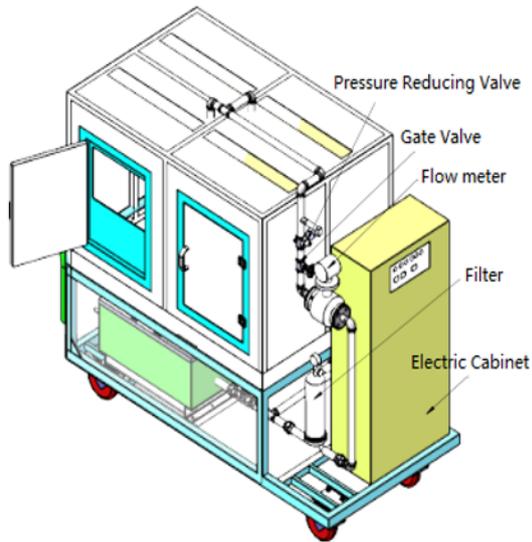


Figure 1. Environmental Chamber

The environmental chamber is used to simulate rain, Fog, light and other environmental conditions, with rainfall, illumination and other detection and display functions. The whole spray system is mainly composed of stainless steel water pipe, stainless steel nozzle, stainless steel valve, precision filter, water pump, metering digital display device and so on. Here, the flow, pressure of water and other parameters can be displayed, and can be controlled.

2.1. Analysis of meteorological factors affecting the laser radar performance

The laser radar has very high resolution of range, angular and velocity, the divergence angle of the laser beam is very small, the laser wave length is short, the information of the target's range, angle, reflection intensity, velocity and so on can be directly acquired, which can create a multidimensional image. But in heavy rain, smoke or fog, the attenuation will be greater, which will be resulting in a much smaller propagation distance of the laser radar. For this reason, the fog, rain and snow are the main influencing factors for the laser radar.

2.2. Analysis of meteorological factors affecting the camera performance

The camera sensor resolution is high, the obstacle type recognition is accurate, it also can capture the object shape, the detail and excel to processing the complex driving environment[3]. But in heavy rain, strong illumination or luminosity transient, video images will appear mold, distortion. For this reason, the fog, rain, snow and illumination are the main influencing factors for the camera sensor.

2.3. Analysis of meteorological factors affecting the inertial navigation equipment performance

The inertial navigation sensor system (INS) has the following advantages, it can get measurement data by using only internal sensors without any outside help; The measurement output of the inertial navigation sensor system can be synchronized with the computer's sampling calculation, and the high sampling rate and operation speed can realize short time delay. Inertial navigation sensor system has its own disadvantages, including: inertial sensor with enough precision is very expensive; the expensive sensor needs a long initialization time; Even if the initial estimation accuracy of the navigation state is very high, there will still be error accumulation when the navigation state is solved by integrating the inertial measurement data including drift or deviation error and noise. To sum up, the complex weather conditions have little influence on the vehicle-borne sensor-inertial navigation equipment[4].

2.4. Analysis of meteorological factors affecting the ultrasonic radar performance

There are two common ultrasonic radar, one is mounted on the front and rear bumpers, used to measure the car before and after obstacles reversing radar, and the other mounted on the side of the car, used to measure the distance of the side obstacles ultrasonic radar. It's same with the laser radar, its transmission speed is greatly affected by the weather, especially in rainy days, it can not accurately measure the distance. For this reason, the fog, rain and snow are the main influencing factors for the ultrasonic radar.

2.5. Analysis of meteorological factors affecting the millimeter-wave radar performance

The millimeter-wave radar can track and classify the object according to the object information, and finally the intelligent processing is carried out by the Central Processing Unit (Ecu). In order to ensure the safety and comfort of the driving process and reduce the risk of accidents, the driver should be informed or warned by sound, light and touch, and the active intervention should be made in time. And it has strong adaptability to atmospheric turbulence, air vortex and noise. But millimeter-wave radar is greatly affected by rainfall, so weather factors are the main factors that affect the performance of millimeter-wave radar[5].

2.6. Analysis of meteorological factors affecting V2X performance

V2X is the key technology of intelligent transportation system in the future. It enables vehicle-to-vehicle, vehicle-to-base station, base station-to-base communication. Thus a series of traffic information

such as real-time road condition, road information and pedestrian information can be obtained, which can improve driving safety, reduce traffic congestion, improve traffic efficiency and provide on-board entertainment information[6]. It connects the car to everything, which is part of the Internet of things, So, V2X is the only vehicle sensing technology that is not affected by weather conditions. However, the electromagnetic environment in the downtown area, the DC charging station area and the shortwave Antenna Tower area is quite complex and harsh. In the complex electromagnetic environment, the attenuation, fluctuation and even failure of its performance will directly affect the safety of the drivers and passengers, therefore, electromagnetic interference is the main reason that affects the performance of V2X equipment.

It turns out that the laser radar, the ultrasonic radar and the millimeter-wave radar has similar working principle, the fog, rain and snow are the main influencing factors. The fog, rain, snow and illumination are the main influencing factors for the camera sensor, which is shown in Table I:

TABLE I. THE INFLUENCING FACTORS OF THE PERCEPTION MODUL

Serial number	On-board sensor	Meteorological factor
1	The laser radar	Fog, rain, snow
2	The camera	Fog, rain, snow, illumination
3	The inertial navigation equipment	None
4	The ultrasonic radar	Fog, rain, snow

TABLE II. SIMULATION SCENE AND ITS MAIN CONTROL INDEXES

Serial number	Weather condition	Simulation scene	Main control indexes
1	Rain	Rainstorm	① Flow ② Pressure ③ Nozzleaperture adjustable ④ Air flow $\geq 3000 \text{ m}^3 / \text{h}$
		Heavy rain	
		Moderate rain	
		Light Rain	
		With rain and wind	
2	Fog	Thick fog	① Stressors (3~10) MPa ② Nozzle aperture $\leq 0.15 \text{ mm}$ ③ Start-Stop Time
		Heavy fog	
		Mist	
3	Light	Bright Light	① Intensity of exposure $\geq 1200 \text{ W}/\text{m}^2$ ② Adjustable Angle
		Shadow mottled	
		Photometric transient	

5	The millimeter-wave radar	Fog, rain, snow
6	V2X	None

3 ANALYSIS OF THE INFLUENCE OF COMPLEX WEATHER CONDITIONS ON ICV PERFORMANCE

By analyzing the influence factors of complex weather conditions on the performance of vehicle-mounted sensors, the characteristics of the complex weather conditions that affect the performance of vehicle-mounted sensors are studied, and the complex weather scenes such as rain, fog, snow and light are proposed, these complex weather scenarios will directly affect or even reduce the performance of the whole vehicle. Therefore, the study of complex meteorological conditions has great significance.

To sum up, the complex weather conditions will have a great impact on the performance of the whole vehicle, which will lead to a decrease in the recognition accuracy of the perception module or even a wrong recognition of the recognition information, this will directly affect the normal road driving of ICV, and cause the occurrence of traffic accidents.

For this reason, building the complex weather condition scene, studying and testing the ICV performance will be very beneficial. Each sensor performance is analyzed in Environmental Chamber , then the scene and control indexes are shown in Table II:

4 CONCLUSION

By analyzing the influence of the weather conditions on each vehicle sensor performance, studying the different weather conditions that affect the ICV performance, the corresponding weather scenes and their control indexes are put forward. The research of simulation scene and its main control indexes provide a basis for the construction of the complex weather scenes, which is great significance to researching the performance test method of ICV under the complex weather condition.

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