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Development Status and Trend of the Intelligent Networked Vehicle Perception System

Hongqing Li, Xuefeng Shi

China Automotive Technology and Research Center Co., Ltd. Tianjin 300300, China

Abstract

The development process of intelligent networked vehicles is the process of car driving from passive safety to active safety, from information islands to comprehensive interconnection. The level of automotive automation depends on the completeness of the intelligent perception system. When the era of autonomous driving is gradually approaching, intelligent sensors will become the core components of intelligent networked vehicles, the entrance of all data collection, and the front end of intelligent perception of the external environment.

Keywords

Smart Car; Perception System; Vehicle-road Collaboration.

1. Development Overview

Sensors in the automotive field are divided into body perception sensors and environment perception sensors according to different applications. The distribution of the two types of sensors represents different development stages of the car and plays different roles. MEMS sensors improve the informatization level of the bicycle itself so that the vehicle can perceive itself. According to the input measured, it is mainly divided into pressure sensors, position sensors, temperature sensors, etc. According to the working principle, most body perception sensors use MEMS solutions. Environmental perception sensors realize the ability of bicycles to perceive the external environment, help the car computer to obtain environmental information and make planning decisions, and provide support for intelligent driving of vehicles. Environmental perception sensors are mainly divided into vehicle cameras, ultrasonic radar, millimeter wave radar, and laser radar.

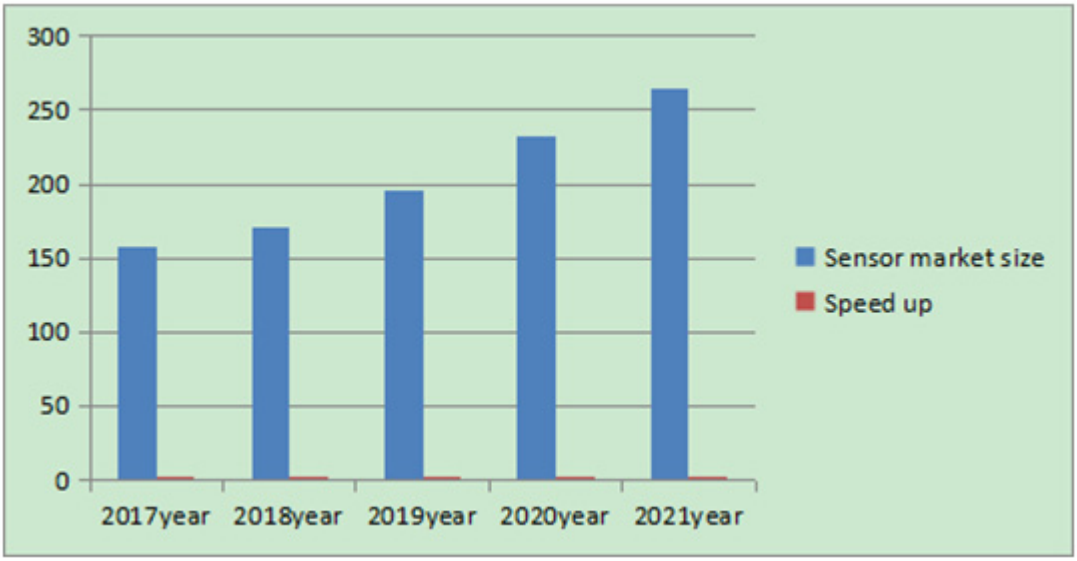

Fig 1. 2017-2021 China's automotive sensor market size (unit: 100 million yuan, %)

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Driven by the rapid development of new energy vehicles and the iterative upgrade of autonomous driving technology, in 2021, China's automobile production and sales will complete 26.082 million and 26.275 million, respectively, a year-on-year increase of 3.4% and 3.8%, respectively, ending the downward trend for three consecutive years. It has contributed an essential force to the sustained recovery and development of China's industrial economy and stable macroeconomic growth. Driven by national policies and the rapid development of smart cars, in 2021, the scale of China's automotive sensor market will be 26.39 billion yuan, an increase of 3.18 billion yuan over the previous year and a year-on-year increase of 13.7%.

In 2021, in China's automotive sensor market, body perception sensor technology was relatively mature, accounting for 28% of the market; with the development of autonomous driving technology, the demand for environmental perception sensors will increase, accounting for 72% of the market. Among the environmental perception sensors, millimeter-wave radar and cameras account for a relatively high market share, accounting for 28% and 23%, respectively.

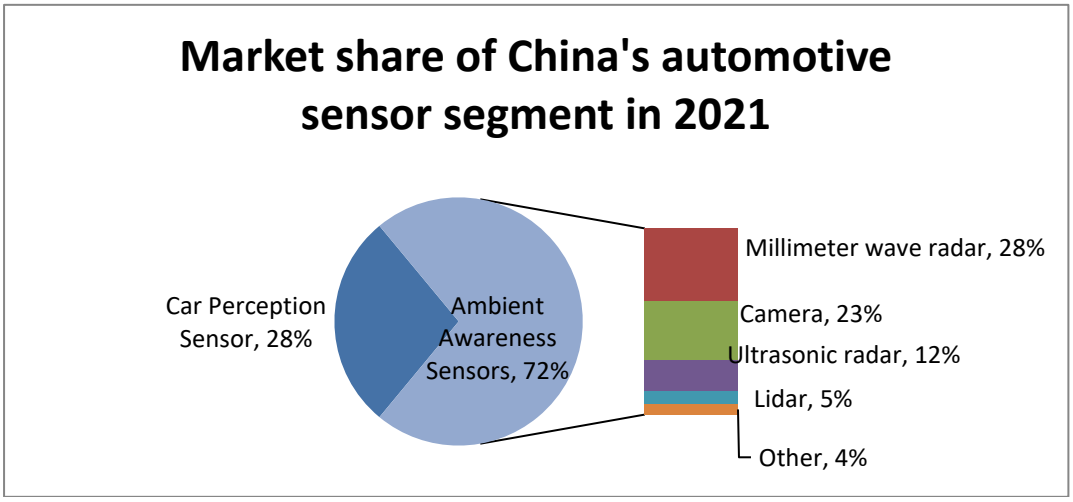

Fig 2. 2021 China's automotive sensor segment market share (unit: %)

2. The Key Areas

Automotive sensors have a long R&D cycle and high added value and are the core hardware for intelligent driving. Comparing cameras, ultrasonic radars, millimeter-wave radars, lidars, and other commonly used intelligent driving sensors, they have their advantages and disadvantages in terms of performance and use., see Table 1.

Table 1. Performance comparison of some intellisense sensors

Parameter	Camera	Ultrasonic radar	Millimeter wave radar	Lidar
Ranging/speed measurement	Ranging and low precision	High precision	High vertical accuracy, low horizontal accuracy	High precision
Cost	Monocular: 500-1000 yuan. Binocular: 1500-2000 yuan	100-200 yuan	500-1000 yuan	>20,000 yuan

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Perceived distance	<100m	<5m	150m-300m	<300m
Response time	Medium, >100ms	slow, 1000ms	fast, 1ms	fast, 10ms
Information	Collect environmental pictures and identify images through algorithms	Unable to form image information	Difficult to form complete environmental information	3D modeling and imaging
Advantage	Recognize road markings and traffic signals	Low price and simple data processing	Not affected by weather and night, long detection distance	Wide detection range, high detection distance/angle accuracy
Shortcoming	Vulnerable to weather, large samples required for machine learning training, and long periods	Affected by weather, short detection distance	Pedestrian reflection wave is weak, object color cannot be recognized, very sensitive to metal surface, poor effect in tunnel	High cost, vulnerable to weather
Application examples	Lane Departure Warning (LDW), Lane Keeping Assist (LKA)	Reversing radar, automatic parking	Adaptive Cruise Control (ACC), Blind Spot Detection (BSD)	Detect traffic information around the vehicle

2.1. MEMS Sensor

MEMS sensors have a long research and development cycle and are not sensitive to the advancement of semiconductor processes. The cost of packaging and testing usually exceeds half of the total cost. In terms of packaging, MEMS are usually divided into chip-level, device-level, and system-level packaging. Most of them use non-standard processes and are manufactured by traditional IC packaging companies. The cost of packaging can account for more than 40% of the total cost; in terms of testing, Compared with integrated circuits, MEMS have higher requirements and greater testing complexity. The testing methods vary according to the types of MEMS sensors. Each manufacturer usually uses self-developed methods for testing, and the cost of packaging and testing can account for more than half of the total cost. There is still a gap between domestic and overseas enterprises in design, manufacturing, testing equipment, and other aspects, and their core competitiveness needs to be improved. In 2020, the scale of China's MEMS sensor market was 70.82 billion yuan, up 14.78% year-on-year, and the average annual compound growth rate is 18.16%, which is faster than the world.

2.2. Vehicle Camera

Vehicle cameras are mainly composed of a lens group, the image sensor (CIS), and digital image signal processing (DSP), of which CIS has the highest cost. The cost of the image sensor in the car camera can reach 50%, and the module package and lens group account for 25% and 14%, respectively. According to the application of the in-vehicle camera in the vehicle, it can be divided into five types: front view, surround view, rear view, side view, and built-in. For the front-view camera, the performance of the binocular is better than that of the monocular, but due to the need for higher computing power chip support, the cost is high, and it is not easy to

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popularize quickly, so it is still dominated by the monocular. ICV Tank predicts that from 2020 to 2025, the global vehicle camera market will increase from US$13.8 billion to US$27 billion, with a CAGR of 15.7%; the Chinese vehicle camera market will increase from 6.4 billion to 23 billion, with a CAGR of 29.2%, the car camera market has broad prospects.

2.3. Ultrasonic Radar

The development of vehicle-mounted ultrasonic radar is relatively mature and has been localized, but there is still a gap in the upstream chip link. For example, the Chinese company Audiwei can independently develop and produce transducer chips for ultrasonic radar applications, but there is a gap with foreign manufacturers regarding R&D investment scale and the number of invention patents. In general, the development of ultrasonic radar is relatively mature, and it is the mainstream sensor for automatic parking solutions, which is expected to benefit from the promotion of automatic parking applications. According to data from a leader and Huajing Industrial Research Institute, the size of China's ultrasonic radar market is 5.17 billion yuan in 2020 and is expected to reach 6.2 billion yuan in 2023.

2.4. Millimeter Wave Radar

Vehicle-mounted millimeter-wave radar is developing towards high precision, small size, and long detection distance, and domestic enterprises have been joining the market competition as their technologies continue to mature. At the end of May 2019, the Senstech 77GHz vehicle-mounted millimeter-wave radar mounted on the Hongqi HS5 became the first ADAS millimeter-wave radar sensor to be genuinely "on the road" in China, breaking through the monopoly of international giants and having mass production capabilities. Companies at the forefront of China's automotive millimeter-wave radar industry mainly include Huayu Automobile, Desay SV, Nava Electronics, Zhibo Technology, Senstech, Huawei, etc.

2.5. Lidar

The different scanning methods divide lidar into mechanical, hybrid solid-state, and solid-state lidar. Mechanical lidar is the first lidar product used in autonomous vehicles. At present, mechanical lidar still occupies the mainstream, with computerized accounting for 66%, hybrid solid-state MEMS accounting for 17%, solid-state Flash accounting for 10%, and others accounting for 7%. The hybrid solid-state solution based on the ToF solution is the mainstream of the current car. Hybrid solid-state lidar is lower in cost than mechanical, more mature than pure solid-state (OPA, FLASH) solutions, and easy to achieve commercialization. It is the first to pass vehicle-level regulations, control the cost, meet the performance requirements of car companies, and can achieve mass production. They have supplied technical solutions. The Xiaopeng P5 is equipped with two radars from DJI's customized dual prism scanning solution, which are installed on both sides of the front bumper; the NIO ET7 is equipped with Innovusion's dual-rotating mirror lidar, which will be mass-produced in the first quarter of 2022.

3. The Development Trend of Intelligent Perception

3.1. Two Solutions to Promote the Development of the Industry

At present, there are two leading solutions for autonomous driving sensors. From the perspective of visual solutions, they are composed of cameras and low-cost components such as millimeter-wave radars to form a pure visual solution. Typical representatives are Tesla, Mobileye, and Baidu ApolloLite. The pure vision solution is lightweight, low cost, conforms to vehicle regulations, and can provide richer environmental information. The disadvantage is that it relies heavily on massive data training. From the perspective of the multi-sensor fusion solution, the multi-sensor fusion solution represented by Waymo is dominated by lidar and has

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a fusion solution of cameras, ultrasonic radar, millimeter-wave radar, and other sensors, including Audi A8, Volvo XC90, etc. Many models have various sensors such as lidar, cameras, ultrasonic radar, and millimeter-wave radar. By integrating a variety of sensors, they form complementary performance advantages and continuously improve the level of autonomous driving. Lidar has high precision and high stability, so it is considered by most OEMs and Tier 1s to be an essential sensor for L3 and above autonomous driving.

3.2. The Intelligent Perception System Develops in the Direction of Vehicle-Road Coordination

Limited by the installation position of the sensor, the sensing range, and the influence of roadside obstacles and the size of the surrounding vehicles, only the on-board sensors cannot fully and accurately perceive the road conditions, while the installation of sensing sensors on both sides of the road can be used for automatic driving. The vehicle provides a "God's view" that complements onboard sensor information. The development of 5G technology also provides a basic communication technology guarantee for the rapid collaboration of vehicle and road sensors. The dense deployment of perception sensors on both sides of the road also relieves the cost pressure of onboard sensors to a certain extent, which is more conducive to the last promotion and application of autonomous vehicles.

4. Problems and Suggestions

4.1. Existing Problems

Driven by technological development and policy support, the "new four modernizations" of electrification, networking, intelligence, and sharing are reshaping the automotive industry. The number of sensors used is rising, and the market size is expanding. While the intelligent perception system is developing rapidly, there are the following problems: First, the core components and chips of intelligently networked vehicle sensors are lacking, and the endogenous development momentum is insufficient. Second, the intelligent sensor industry is a relatively weak link in the intelligent networked automobile industry, with many restrictive factors. Third, the ability to transfer and transform scientific and technological achievements of intelligent sensors is insufficient, and the linkage coordination mechanism needs further improvement.

4.2. Development Suggestions

Adhere to the market orientation, improve the competitiveness of industrial development, give full play to the decisive role of the market in resource allocation, better play the role of the government, establish a collaborative innovation mechanism integrating production, education, research, and use, and promote "chip-integration-system-information" Effective collaboration between service" enterprises, shorten the R&D cycle from technology to product, rapidly improve the R&D capability of technical products, and achieve industrial breakthroughs and development.

Strengthen the top-level strategic design and consolidate the foundation for industrial development. Carry out remarkable planning work for the smart sensor industry, clarify critical areas and projects, establish special funds to support key projects and key technology areas, and promote cross-industry and cross-departmental coordination. At the enterprise level, based on actual needs, do an excellent job in top-level planning and design, clarify the development priorities of each stage, and achieve innovative breakthroughs in key goals and fields.

Promote the construction of the brand system and enhance the connotation of industrial development. Increase policy and financial support, support fundamental technology research and development, build a group of leading enterprises and brands, promote the transformation

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and pilot testing of scientific and technological achievements, and strengthen the standard formulation, supervision, and management of intelligent sensors. At the enterprise level, increase the investment in research and development of core technologies and personnel, improve the product quality management system, adhere to the road of quality + quality + brand, identify the enterprise's positioning, and improve the matching ability with the brand.

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