



REVIEW

The Comparison of Current Development, Technology and Governments' Attitudes of Driverless Car at Home and Abroad

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ARTICLE INFO

Article history

Received: 5 August 2019

Accepted: 20 August 2019

Published Online: 30 October 2019

Keywords:

Driverless car

Current development

Technology

Governments' attitudes

Future development direction

ABSTRACT

Driverless car, as a direction for future automobile development, greatly improves the efficiency and safety of the traffic system. It's one of the most popular technical fields. In recent years, driverless car has developed rapidly. The related development is concerned by governments, businesses, consumers and stakeholders widely, and most of countries have been actively studying this technology. This paper first introduces the current development of driverless car at home and abroad. Besides, the basic technologies of driverless car are briefly analyzed. In addition, the author compares the American government's attitudes with Chinese government's attitudes towards driverless car. Specifically, the article makes an analysis of contents of literature and periodicals at home and abroad and policies and documents which have already been published. The analysis shows that there is no great difference between the attitudes of Chinese and American governments. Both of two governments actively support the development of driverless car. Finally, this paper expounds the development direction of the driverless car field in future by dividing into two categories through road conditions: automatic driving on expressways and automatic driving in cities.

1. Introduction

A driverless car is a vehicle that is capable of sensing its environment and navigating without human input. Driverless cars use a variety of techniques to detect their surroundings, such as radar, laser light, computer vision, GPS, IMU and so on. The potential benefits of driverless cars include reducing mobility and infrastructure costs, increasing safety, increasing mobility, increasing customer satisfaction and reducing crime^[1]. In recent years, driverless cars have been developing rapidly. The National Highway Traffic Safety Administration (NHTSA) and the Society of Automotive

Engineers (SAE) have all graded automatic driving technology (see Table I), which, to a certain extent, represents the development phase of the driverless technology^[2]. In China, the driverless technology has developed well with the encouragement and support of the government. Beijing, Shanghai and some other cities have promulgated the detailed rules of automatic driving road test. In 2014, Google fired a shot heard all the way to Detroit. Google's newest driverless car had no steering wheel and no brakes. The message was clear: cars of the future will be born fully autonomous, with no human driver needed^[3]. Companies, such as Uber and Waymo, are also actively testing driverless cars hoping for combining autopilot technology

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with car calling services. In Dubai, the first driverless taxi in the world was put into operation by the Dubai highway and Transport Administration (RTA) in February 28, 2018. These show that the automotive industry is undergoing a revolution. It is obvious that driverless cars are likely to be widely applied in the future, which has great certain research significance.

However, no one has investigated both of the technology and governments' attitudes of driverless cars at home and abroad so far. There are few book resources about this topic. But there are many Internet sources and periodical sources that appear to be reliable. Contents of literature and periodicals at home and abroad and policies and documents which have already been published are analyzed.

Table 1. Automatic Drive Classification

Automatic Drive Classification		Name (SAE)	Main Part			
NHTSA	SAE		Driving Operation	Peripheral Monitoring	Support	System Scope
0	0	No Automation	Human Drivers	Human Drivers	Human Drivers	System Scope
1	1	Driving Support	Human Driving System			None
2	2	Partial Automation	System	System	System	Part
3	3	Conditional Automation				
4	4	Highly Automation				
	5	Complete Automation	Whole Domain			

2. The Development Status of Driverless Car in Foreign Countries

In the early 1970s, the developed countries such as the United States have already begun to study driverless car technology. In 1995, Carnegie Mellon University developed the Navlab series of driverless cars, which completed the pilotless experiment across the eastern and western parts of the United States. In 2005, in the "big challenge" competition organized by the United States Department of defense, the multi-functional driverless car launched by Stanford University realized long distance travel on the rugged road.

In recent years, as Google, Tesla, BMW and other famous companies have joined the research of driverless cars, unmanned technology has made great progress. In July 2014, BMW and Baidu Inc established long-term cooperation on driverless cars. By the end of 2015, the driverless car jointly developed by them successfully completed the

mixed test of urban road and high-speed traffic conditions. In 2015, Toyota Corporation, cooperated with Standford and University of Michigan, allocated 1 billion to the autopilot project. In 2016, Toyota Corporation invested strategically in American Technology Corp Uber, and also established the cooperative relationship in the research of driverless technology. In 2016, Ford Fusion ushered in the debut of the driverless car. Google has built an independent automated driving company Waymo. Its actual test mileage of driverless car has reached about 2 million miles. In March 2017, Tesla launched the Autopilot 8.1 system on the basis of Autopilot 2, greatly improving the grade of the driverless car. According to statistics, Tesla has been driving over 222 million miles in the Autopilot mode^[4].

3. The Development Status of Driverless Car in China

The development of domestic driverless vehicle is lagging behind compared with other developed countries.

In 1992, National University of Defense Technology developed the real driverless car in China. In 2000, the fourth generation of driverless cars developed successfully with a speed of 76km/h. In 2005, Shanghai Jiao Tong University developed the first urban driverless car. Since 2009, with the support of the National Natural Science Fund, the "China smart car future challenge", the only competition aimed at driverless car in China, has been successfully held for eight sessions. It has played a great role in promoting the development of driverless cars in China. In 2010, the pilotless car developed by the National University of Defense Technology and FAW has realized autonomous navigation without human intervention, and can drive stably on high speed roads.

After 2013, IT giants in China and some large autonomous vehicle companies gradually joined in the field of technology development in the field of driverless vehicle. The unmanned pilot project, led by the Baidu Institute for deep learning and research, started in 2013. In 2015, Baidu realized the road test of the driverless vehicle. At the same time, it announced the establishment of the automatic driving department, and plans to complete commercialization as soon as possible. In addition, BYD and other auto companies have gradually stepped into the field of self driving^[5].

In 2016, Baidu Inc and Ford automobile company invested in laser radar manufacturer Velodyne, hoping to reduce the production cost of driverless car laser radar. In addition, Baidu has started to work with NVIDIA, a global graphic technology and digital media processor industry leader, to form an automatic driving platform. At

the same time, Jingdong announced that its unmanned vehicle began to enter the road test phase and planned to run the test and may be able to use it on a large scale in 2017. Didi announced that driverless car would be one of their major strategic layouts, and will soon achieve the goal of carrying a passenger car on a driverless car.

4. The Basic Technologies of Driverless Car

The most important part of driverless car is the automatic driving system, which mainly consists of three parts: environmental perception, vehicle location and navigation, and motion control. These three aspects complement each other and constitute the foundation of driverless car^[6].

4.1 Environmental Perception

In the driving process, people need to observe and analyze the state of the vehicle itself, other vehicles, pedestrians, road, traffic lights and so on, which is called the perception of the traffic environment. This perception first obtains information through multi-senses, and then uses information and experience to make sense information and make decisions. Like people, driverless car also needs to perceive the environment when driving autonomously. Environmental perception, which is similar to the driver's eyes, usually made up of camera devices, sensors, and so on. It is used to perceive the driving environment, and then to produce behavioral decisions based on the useful environmental information obtained.

4.2 Vehicle Location and Navigation

Vehicle location and navigation is similar to the driver's map. Currently, the most commonly used technologies include magnetic navigation and visual navigation. Among them, magnetic navigation is the most mature and reliable scheme at present. The biggest advantage of magnetic navigation is that it's not affected by natural conditions such as weather. However, magnetic navigation methods often need to bury certain navigation devices on the road, and the implementation process is cumbersome. The advantage of visual navigation is that it can prevent cars deviate from the target lane. But with low visibility caused by natural factors, the navigation system will not work. Due to the low requirement for infrastructure, visual navigation is generally recognized as the most promising location method.

4.3 Motion Control

Motion control system is similar to the driver's brain, which is used to analyze road information. It's based on the driving trajectory, speed planning and the current position, posture and speed of the driverless car. And then it

produces control

commands for the throttle, the brake, the steering wheel and the transmission lever to track the planned trajectory and send out the corresponding instructions. At present, the most commonly used method is the classical intelligent PID algorithm.

5. Governments' Attitudes Towards Driverless Car

5.1 The United States

The United States is the leader in the development and application of driverless car in the world. The U.S. Department of Transportation (DOT) published the world's first self-driving cars policy document Federal Automated Vehicles Policy in September 20, 2016^[7]. This policy includes the policy objectives and Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems. The previous day, President Obama introduced a new deal in Pittsburgh Post-Gazette: "Automated vehicles could change their lives. Safer, more accessible driving. Less congested, less polluted roads. That's what harnessing technology for good can look like. But we have to get it right. That's why my administration is rolling out new rules of the road for automated vehicles – guidance that the manufacturers developing self-driving cars should follow to keep us safe."^[8]

5.2 China

In November 15, 2017, China's Ministry of science and technology announced that it would rely on Baidu to build a new generation of automatic driving national innovation platform. In December 18, 2017, the Beijing Municipal Transportation Committee, the Public Security Management Bureau, the Economic Information Committee and other departments issued two guiding documents on the guidance of speeding up the road test of automatic driving vehicles and the detailed rules for the implementation of the road test management for automatic driving vehicles^[9]. It's clearly pointed out that the independent legal entity registered in China can apply for temporary driving on account of automatic driving related research and stereotype test. Beijing has taken the lead in making a complete set of laws and regulations for driverless car. To a certain extent, it supports the development and popularization of driverless car.

6. The Future Development Direction of the Driverless Car Field

The development direction of driverless car can be divid-

ed into two categories through road conditions: automatic driving on expressways and automatic driving in cities.

The driving environment and traffic signs on the freeway are relatively better, but long time driving at high speed is rather boring for drivers. The application of driverless car in this direction can solve this problem well, and also can effectively improve the efficiency and safety of traffic. In the future development, as long as driverless car completes the mark line tracking and vehicle identification function on a well structured highway, and can avoid the same track as far as possible, the full automatic driving of the highway can be achieved successfully.

In cities, there are more vehicles and people on the road. Additionally, the environment is much more complex. In the autonomous driving test which took place in Parma in July 2013, the vehicle has proven to be able to drive autonomously, without any human intervention, sharing roads with other vehicles, and manage roundabouts, intersections, priority roads, stops, tunnels, crosswalks, traffic lights, highways, and urban roads. But one of the aspects that need to be further investigated and developed is the driving efficiency and speed: the test was carried out considering safety as a priority, and the most complicated maneuvers were carried out at a reduced speed. Plus some perception problems still have to be solved: the problem of merging in large and multi-lane roundabouts, where vehicles travel at high speeds, has not been completely solved^[10]. So it still needs further technical support and research, and puts forward higher requirements for the technology.

7. Conclusions

This paper investigates the current development of driverless cars at home and abroad, analyses the basic technologies of driverless cars, compares the American government's attitudes with Chinese government's attitudes towards driverless cars, and expounds the future development direction of the driverless car in two ways.

The results indicate that the development of driverless cars would be the development direction of the automotive industry in the future, and plays an important role in promoting the technology innovation in automobile industry. With the development of economy, science and tech-

nology, people would use intelligent driverless cars in the near future. It is a kind of intelligent car, which combines detection, identification, judgment, decision, optimization, optimization, execution, feedback, and control function. It also can learn, summarize and improve skills. Besides, it integrates the top scientific and technological achievements such as microcomputers, green environment power system, new structure material and so on. The driverless technology at home and abroad is developing continuously, and its function and reliability are constantly improving. What's more, further improvements are needed in the aspects of security, intelligence and regulation of driverless cars.

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