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Review on the Development of Autonomous Driving Technology

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Abstract: Unmanned driving is considered to be a highly disruptive technology in the field of vehicle engineering. Using expert interviews, comparative analysis, and literature research, this paper presents an analysis of development trends and stages of driverless technology and evaluates the potential benefits and social impacts of driverless vehicles. Furthermore, ways to promote the development of self-driving technology by strengthening the research on automobile drive-by-wire control technology, energy power technology, and cognitive driving technology are also proposed.
Keywords: disruptive technology; unmanned driving technology; automotive wire control technology; energy power technology; cognitive driving technology

Autonomous driving is considered one of the most disruptive technologies of the twenty-first century [1]. Driverless cars are being developed to have the ability to learn and explore autonomously and to handle various complex road conditions. Accordingly, the car of the future will be a self-learning wheeled robot. The work and cooperation between human beings and such wheeled robots can be divided into the following four stages: first, the wheeled robot records data and learns while the human is driving; second, the human supervises the self-driving wheeled robot; third, the wheeled robot drives and learns without human intervention; fourth, the wheeled robot teaches the human how to drive more effectively [1]. In this manner, automobiles of the future will not only learn human driving skills but also independently explore and master driving skills in complex environments. With the collection of massive amounts of driving data and the continuous improvement of intelligent technology, the core technology of autonomous driving will continue to improve.

1 Industry development trends in autonomous driving technology

Road-based traffic is the primary means of ground-based transportation, and road traffic accidents have been a concern for society since the dawn of the automotive industry. Although road traffic accidents in China have declined significantly in recent years (according to statistics published by relevant departments), China still ranks second in the world in terms of the annual death toll due to road traffic accidents [2]. Therefore, a new and safe mode of driving is urgently required to improve this situation.

In recent years, with intelligent technology gradually entering the automotive industry, automotive intelligence has made driving much safer and more convenient. Autonomous driving technology can achieve automatic driving through the use of intelligent software and a variety of sensing devices, thus comprehensively mitigating accidents during driving. Further, the development of intelligent technology has stimulated people's demand for automobile safety and intelligent vehicles. The Institute of Electrical and Electronics Engineers (IEEE) has forecast that the proportion of driverless automobiles will continue to rise and will reach 75% by the year 2040 [3].

At present, technological development in the autonomous driving field is following both progressive and disruptive paths [4]. The progressive path refers to intelligent sensors and communication equipment installed in automobiles that can analyze road conditions in real-time and thus achieve autonomous driving. Most automobile

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manufacturers are following this path. In the disruptive development path, automobile manufacturers are skipping the initial levels and are directly developing Level 4 and 5 autonomous driving vehicles. For example, non-traditional automobile companies such as Google and Uber are developing driverless cars that boast of comprehensive perceptual skills, cognitive competence, and execution capacity and can be regarded as intelligent mobile robots on the road. At present, automobiles are mostly driven manually, and although assisted-driving technology is developing rapidly, autonomous driving has not yet reached the commercialization stage.

2 Development stages of autonomous driving technology

Autonomous driving requires nine specific technologies: vehicle-to-vehicle communication, cruise control, automatic braking, video cameras, position estimators, and global positioning systems [5]. The automated driving stage is defined by six levels: Level 0 (without automation), Level 1 (driver-assistance), Level 2 (partially autonomous), Level 3 (conditionally autonomous), Level 4 (highly autonomous), and Level 5 (fully autonomous).

In China, autonomous driving technology is still at the initial development stage. In 1980, the development of “remote-controlled reconnaissance vehicles for nuclear and chemical damage protection” was approved by the state. The National University of Defense Technology has been at the forefront of automotive intelligence technology. It developed China’s first intelligent car in 1989 and China’s first truly driverless car in 1992. In 2011, the driverless car developed by the National University of Defense Technology passed the driverless freeway experiment. In 2012, the Academy of Military Transportation of the Chinese People’s Liberation Army successfully developed the first intelligent driverless car that was officially certified in China for high-speed testing [6].

3 Development evaluation of autonomous driving technology

3.1 Basic overview of autonomous driving technology

The concept of “autonomous driving” was first proposed by Norman Bell Geddes, an American industrial designer [7]. The research and development of autonomous driving technology have attracted Chinese and foreign automobile giants, such as Volvo Group, Daimler Automobile Company, SAIC Motor, FAW, GAC Group, and BYD. Furthermore, it has attracted various universities, and scientific research institutions, such as Carnegie Mellon University, Stanford University, Chinese Academy of Sciences, CASIC (China Aerospace Science & Industry Corp.), Third Research Institute, National University of Defense Technology, Beijing Institute of Technology, and the so-called new forces in the automotive industry such as Apple, Google, and Baidu.

3.2 Potential benefits of autonomous driving technology

Autonomous driving technology will not only favorably promote the growth in automotive industry consumption, but also revitalize and optimize the entire automotive industry structure. In addition, technological advancements will create new business opportunities for the automobile industry. For example, shared cars will become more popular. With advancements in automotive intelligence, further infrastructures will benefit, such as the logistics industry and road traffic [8]. Enterprises possessing core technical intellectual properties will take the lead in the “second half” of the shared car industry and realize its profits. Autonomous driving technology can enable users to interact with cars seamlessly, thus reducing labor costs for vehicle operation and maintenance. Moreover, the application of advanced technologies such as facial recognition and big data has also reduced the risks to shared car operators.

The potential value of autonomous driving includes massive data accumulation, time and cost savings, and convenience for disabled people, and will also promote the healthy development of the automobile and travel industries.

3.3 Social impact of autonomous driving technology

Autonomous driving technology will have a significant impact on society. Finance, energy, transportation, and other social norms and industrial structures, which are constructed based on the traditional automobile industry, will need to be revised to adapt to the impact of autonomous driving technology [7]. Although autonomous driving technology has not yet reached the commercialization stage, relevant laws and regulations need to be studied and formulated.

Autonomous driving technology will enable cars to think independently and handle most situations autonomously by utilizing big data and deep learning. The relationship between this technology and humans will be more complex, and future development and promotion will be a long-term process. Taking labor employment as an example, General Motors closed its old factories due to technological innovations in its production, resulting in a large number of unemployed people. After the popularization of autonomous driving technology, taxi drivers may be the first to be affected. The resolution of other similar issues needs pre-emptive, comprehensive planning and further study.

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3.4 Development and analysis of autonomous driving technology in China and overseas

The industry generally believes that the development trend of automobile technology is toward autonomous driving. Based on this trend, Chinese and international Internet companies have joined the bandwagon in research and development of autonomous driving technology, which may soon become the most disruptive technology [9]. See Table 1 for a comparison of the domestic and overseas development stage of driverless cars [8].

Table 1. Comparison of driverless vehicles in China and overseas.

Research institutions	Existing achievements	Current shortcomings	Development trend
Google	Pioneer in autonomous driving technology and licensed to legally operate autonomous driving vehicles on the road in Nevada	Prototype stage (imperfect vehicle-vehicle interaction)	With the press of a button, the user can be transported to their destination.
Daimler	Concept Car – F015 Luxury in Motion	Immature multi-source technology; requires higher technical support.	Makes driverless cars be not just a simple means of transportation, but also become the third living space for humanity.
Tesla	Electric descent, autonomous driving system matching vehicle models well	Its development time is still short, and the starting point for ideas and technology still need to be considered.	The NEV technology has become mature, with autonomous driving technology gradually being perfectly integrated.
Baidu Research Institute	Launched the research and development plan for “Baidu Driverless Vehicles” and built a “Driverless Vehicle Operating Area” in Wuhu	Started relatively late; system development needs to be strengthened and improved.	Integrate deep learning and artificial intelligence into autonomous driving systems.
FAW	Red Flag HQ3 successfully launched and symbolizes autonomous driving technology development in China.	Independent research and development, high cost, and limited to specific vehicle models.	Strengthen exchange with foreign organizations and popularize universal autonomous driving systems.
CHANGAN	Completed first 2000 km long-distance test of driverless vehicles in China	The vehicle needs manual intervention and is not flexible enough under complex road conditions.	Develop intelligent interconnected driverless vehicles to help the development of autonomous driving technology in China.

For autonomous driving, Internet companies are following a more disruptive development path compared to traditional vehicle manufacturers. Traditional vehicle manufacturers are evolving from driving-assistance to advanced driving-assistance systems and finally to autonomous driving utilizing existing mature automobile manufacturing technology. However, Internet companies do not have a history of automobile manufacturing. They started developing driverless cars using advanced technologies, such as artificial intelligence, high-precision maps, and light detection and ranging (LIDAR), in the hope of producing the highest-level driverless cars [10].

Enterprises are trying various ways to achieve autonomous driving. In terms of environmental perception, Tesla and other manufacturers have integrated a variety of sensors, used video and image analysis, and prioritized visual perception. Google, Baidu, and other companies are prioritizing LIDAR, assisted by other sensors. With respect to driving decisions, chips and algorithms are playing a dominant role. With respect to action control, one is indirect (based on planning-tracking), and the other is direct (based on artificial intelligence), which can simulate drivers’ brains in perceiving information and then making judgments and taking actions to realize autonomous driving [7].

4 Corrective measures and suggestions for promoting the development of autonomous driving technology

Although autonomous driving technology is developing rapidly, there is still a long way to go before it can be truly commercialized. China’s automobile industry is still experiencing problems, such as low levels of maturity in critical technologies and significant issues related to non-localization of spare parts; further improvements are required with respect to current policies and regulations. As far as promoting the development of autonomous driving technology, we need to start from the following three aspects to accelerate its rapid development [11].

4.1 Vigorously develop drive-by-wire technology

Drive-by-wire technology, which performs vehicle functions that traditionally need to be performed by humans, will become the basis of automotive intelligence. Breakthroughs in technologies such as throttle by wire, steer by wire, brake by wire, and shift by wire will greatly promote the intelligent development of automobiles.

4.2 Achieve significant breakthroughs in energy and power technologies

Owing to onboard sensors, computers, data communication systems, equipment weight gain, and other reasons, autonomous vehicles demand significantly higher power consumption requirements compared to traditional automobiles. Existing fuel-based, fuel-electric hybrid, and pure electric vehicles still have shortcomings in terms of power supply capacity and are insufficient to support the electricity demand of autonomous vehicles long term. Hydrogen fuel cells and solar vehicles have good development prospects and should be the focus of research in automotive energy technology.

4.3 Continuously improve cognitive driving technology

Driverless cars need to learn from the human driving experience to reach and surpass the human driving level. Accordingly, cognitive driving technology needs to be continuously improved through standardization of driving cognition, online learning, predictive control, and other means.

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