Original Research Article

Analysis of the development of driverless technology--Taking Apollo go as an example

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Abstract: In the contemporary era of rapid technological advancements, driverless technology has emerged as a pivotal force reshaping the automotive and transportation landscapes, captivating global attention.This paper zeroes in on Apollo Go, a prominent player in this domain, to conduct an in-depth exploration.By meticulously dissecting its current developmental status, we aim to unearth the hurdles it confronts and the corresponding countermeasures devised.Over the past decades, relentless efforts have been poured into driverless technology research, gradually transitioning it from theoretical constructs and laboratory experiments to real-world applications that permeate daily travel.China, leveraging its policy support, substantial technological reservoir, vast market potential, and sophisticated infrastructure, has wholeheartedly engaged in the R&D and promotion of this technology.A multitude of cities across the nation have been actively involved in constructing intelligent connected vehicle testing zones.As of March 2025, an impressive tally of 17 national-level such zones has been established, with open test roads stretching over 32, 000 kilometers, thereby laying a solid foundation of rich scenarios and copious data for driverless technology trials.Amidst this backdrop, Apollo Go has distinguished itself, playing a significant role in propelling the commercialization of the technology and injecting a fresh stream of vitality into the industry.It has become a benchmark for others to learn from and emulate, making it a prime focus for in-depth study in the quest to understand the nuances and future trajectories of driverless technology. The comprehensive analysis not only furnishes invaluable insights for the evolution of the driverless technology sector but also serves as a catalyst for China's driverless technology industry to stride forward sustainably and healthily.

Keywords: Driverless technology, Apollo go, development analysis

1. Introduction

1.1. Research background and significance

1.1.1. Research background

The continuous development of science and technology has promoted the progress of all walks of life and has had an increasingly significant impact on daily life.As a typical technology under current development, driverless technology has brought great changes to people's travel lives.Since the 1970s, the research on driverless vehicle technology has been carried out.After continuous research and development, remarkable progress has been made.It has evolved from the initial theory and laboratory research to application in daily life.

China, relying on advantages such as policy support, technological accumulation, a large market, and complete infrastructure, actively engages in the research, development, and application promotion of driverless technology.Many cities across the country have launched the construction of intelligent connected vehicle testing areas.As of March 2025, China has established 17 national-level intelligent connected vehicle testing areas, with the total length of open test roads exceeding 32, 000 kilometers, providing rich scenarios and data support for the practice of driverless technology[1]. At the same time, a number of representative enterprises such as Apollo Go have emerged in the driverless field.They not only promote the commercialization process of the

technology but also inject new vitality into the development of the entire industry.

1.1.2. Research significance

Theoretically, in-depth research on the development of driverless technology represented by Apollo Go helps to enrich and improve the theoretical system of the driverless technology field and promotes further academic discussion and innovation in driverless technology.

In practical terms, the practical experience of Apollo Go in the driverless field has important reference value for the entire industry.The challenges it faces and the solutions during the technology application process provide valuable practical guidance for other enterprises, helping to accelerate the improvement of the overall technical maturity of the industry.It also helps government departments formulate more scientific and reasonable policies and regulations, improve the industry supervision system, and create a favorable policy environment for the healthy development of driverless technology.

1.2. Research methods

This paper adopts a variety of research methods to ensure the comprehensiveness and in-depth nature of the research.

In terms of the literature research method, a wide range of relevant domestic and foreign literature on driverless technology is consulted, including academic journal papers, industry reports, patent documents, and government policy documents.Through the collation and analysis of these documents, an understanding of the development history, current research status, and future trends of driverless technology is obtained, laying a solid theoretical foundation for the research of this paper.

Regarding the case analysis method, Apollo Go is selected as a typical case, and its technological development path, operation mode, market expansion strategy, and the challenges and opportunities it faces are deeply studied.Through a detailed analysis of Apollo Go, its successful experience and shortcomings are summarized, providing practical references for the development of driverless technology.

2. Current development status of driverless technology

2.1. Global development trend

Since the rise of driverless technology, it has attracted widespread attention and investment globally.Many countries and regions have actively laid out plans to promote the continuous development of this technology.

The United States, as a frontier of scientific and technological innovation, started relatively early in the driverless field and has a number of powerful enterprises.Tesla, with its advantages in the electric vehicle field, actively develops the Autopilot intelligent driving assistance system, which has greatly promoted the development of the industry and led the development trend of the integration of electric vehicles and autonomous driving.Waymo, a subsidiary of Google's parent company Alphabet, focuses on the research and development of driverless technology and became the world's first company to provide fully driverless taxi services to the public in 2020.Cruise, owned by General Motors, has also made remarkable progress in the driverless field.In June 2022, it obtained approval from California regulators to provide paid driverless taxi services in San Francisco.Although it was affected by accidents later, it is still constantly exploring technological improvement and business expansion.

In Europe, countries such as Germany and the United Kingdom are also actively promoting the development of driverless technology.As a powerful country in the automotive industry, Germany's automotive giants such as Mercedes-Benz and BMW, relying on their profound automotive manufacturing technology foundation, increase their investment in the research and development of autonomous driving technology.Mercedes-Benz's Level 3 autonomous driving system has been approved by the German Federal Motor Transport Authority

(KBA), achieving a certain degree of commercial application and providing users with a more intelligent driving experience.The United Kingdom focuses on the cooperation between industry, academia, and research. Through the joint research of universities and research institutions and the government's financial support for related projects, it has achieved positive results in the basic research and application scenario exploration of driverless technology.For example, it is at the forefront of the world in the research of intelligent transportation system integration and vehicle-road coordination technology.

2.2. Domestic development status

The development of domestic driverless technology has shown a good trend in recent years and achieved remarkable results.Domestic enterprises and research institutions have actively invested and made important breakthroughs in multiple key technology fields.Universities such as Tsinghua University and Tongji University have played an important role in the basic research of driverless technology.They have carried out in-depth research in key technology fields such as environmental perception, path planning, and decision-making control, providing theoretical support for the development of the technology.Domestic enterprises have also made remarkable progress in hardware fields such as sensor technology and communication technology.For example, Huawei's research on the integration of 5G communication technology and the Internet of Vehicles has laid a foundation for realizing high-speed and stable communication between vehicles (V2V) and between vehicles and infrastructure (V2I), improving the real-time perception and response ability of driverless vehicles to complex traffic environments.Technology enterprises represented by Baidu, relying on their technical accumulation in artificial intelligence, big data, cloud computing, and other fields, vigorously develop driverless technology. Baidu's Apollo autonomous driving platform has become a leading open-source autonomous driving platform in China, attracting many enterprises and developers to participate in the ecological construction[2].Based on the Apollo platform, Baidu launched the Apollo Go driverless travel service, which has achieved commercial operation in multiple cities.

In addition, under the guidance and support of government policies, remarkable results have been achieved. As of March 2025, China has established 17 national-level intelligent connected vehicle testing areas, with the total length of open test roads exceeding 32, 000 kilometers, providing rich data and scene support for the practical application of driverless technology.

3. Development history and current status of Apollo go

3.1. Development history

Apollo Go is an autonomous driving travel service platform under Baidu.The emergence of this platform reflects Baidu's long-term exploration and unremitting efforts in the field of driverless technology.In August 2021, Baidu officially launched Apollo Go, providing commercial operation and diversified value-added services to the public, marking a new stage of the commercial operation of Baidu's driverless technology.Since then, Apollo Go has rapidly deployed in many cities across the country.In 2022, it successively launched commercial operations in regions such as Shenzhen, Beijing, Chongqing, Hefei, and Shanghai.At the end of 2022, Apollo Go was among the first batch to be approved for conducting fully driverless autonomous driving tests in Beijing, further promoting the maturity and application of its technology.In 2023, according to Baidu's annual report, the cumulative number of orders for Apollo Go exceeded 5 million.

In May 2024, Baidu achieved a major breakthrough in technology research and development, releasing the world's first large model for Level 4 autonomous driving, ApolloADFM, and the Apollo Go driverless vehicle equipped with the sixth-generation intelligent system solution.The overall vehicle cost decreased by 60% compared with the previous generation, significantly enhancing the product's competitiveness.In the same month,

Wuhan officially put 1, 000 Apollo Go vehicles into operation, and the scale effect began to emerge.In July 2024, the number of orders for Apollo Go in Wuhan experienced an explosion.The peak number of orders per vehicle per day exceeded 20, reaching the same level as that of taxi drivers' daily orders.The total number of orders has exceeded 6 million, and the test mileage has exceeded 100 million kilometers, further demonstrating the feasibility of its business model and market potential.

3.2. Current operation status

As of 2025, Apollo Go has carried out operations in many cities across the country, achieving remarkable results and becoming a leader in the domestic driverless travel service field.Judging from the operation data, the number of orders for Apollo Go has continued to grow.In the third quarter of 2024, the number of autonomous driving orders provided by Baidu's autonomous driving service Apollo Go was 988, 000, a year-on-year increase of 20%.In some key operating cities, such as Wuhan, the scale effect and market influence of Apollo Go are particularly significant.

In terms of the operation area, Apollo Go has opened manned test operation services in 11 cities and carried out fully driverless autonomous driving travel service tests in cities such as Beijing, Wuhan, Chongqing, Shenzhen, and Shanghai.In these cities, Apollo Go actively expands the operation scope and optimizes the operation network through cooperation with local governments and enterprises.In Wuhan, Apollo Go has cooperated with the local government to continuously expand the operation area and increase the number of vehicle deployments, achieving large-scale operation in some areas.At the same time, Apollo Go is also actively exploring cooperation opportunities with other cities and plans to further expand its operation territory, promoting the driverless travel service to more regions.

4. Challenges and measures in the development of Apollo go

4.1. Challenges faced

Although Apollo Go has made remarkable progress in driverless technology and operation, it still faces many challenges during the development process.

At the technical level, although Apollo Go's driverless technology is relatively mature, in complex and changeable traffic environments, there are still some technical problems that need to be solved urgently.Under extreme weather conditions, such as heavy rain, blizzard, and thick fog, the performance of sensors will be seriously affected, resulting in a decrease in the accuracy of environmental perception.In thick fog, the detection distance and accuracy of lidar will be greatly reduced.In heavy rain, cameras may experience problems such as blurred images and recognition errors, which increases the safety risks of vehicles driving in extreme weather. Currently, the decision-making and planning algorithms still have certain limitations in handling these complex scenarios and need to be further optimized and improved.

In terms of cost, the research, development, and operation costs of driverless technology remain high, bringing great economic pressure to Apollo Go.In terms of research and development costs, in order to maintain technological leadership, Apollo Go needs to continuously invest a large amount of funds in technology research and development, including algorithm optimization, sensor upgrades, and hardware equipment updates. The cost of a driverless vehicle equipped with advanced sensors and computing equipment can be as high as hundreds of thousands or even millions of yuan, which poses a cost obstacle to large-scale promotion.In terms of operation costs, a large amount of funds are required for vehicle maintenance, software system updates and maintenance, data storage and processing, etc.In addition, since the driverless technology is not yet fully mature, in order to ensure safe operation, professional technical personnel need to be equipped for remote monitoring and emergency handling, which also increases the labor cost.

User acceptance is also an important issue faced by Apollo Go.Although driverless technology has many advantages, some users still have concerns about its safety.Some users worry that in emergency situations, the driverless system cannot make timely and accurate responses like human drivers, which may lead to traffic accidents.Some users also question the riding experience of driverless vehicles, such as the smoothness and comfort during the vehicle's driving process.In addition, due to the relatively fixed operation areas and routes of driverless vehicles, some users believe that their flexibility is not as good as that of traditional taxis and ride-hailing services, which to a certain extent limits travel choices.

4.2. Countermeasures

In response to technical problems, Apollo Go has increased its research and development investment and formed a professional technical team, committed to solving technical problems in extreme weather and complex traffic scenarios.In terms of sensor technology, the research and development team is exploring new sensor materials and technologies to improve the performance stability of sensors in harsh environments.By optimizing the transmission and reception technology of lidar, the detection accuracy and distance in weather conditions such as thick fog and heavy rain are improved.In terms of algorithm optimization, deep learning and reinforcement learning technologies are used to enable vehicles to continuously learn and adapt to various complex traffic scenarios, improving the accuracy and flexibility of decision-making and planning.By simulating a large number of scenarios such as road construction and traffic accidents, the decision-making and planning algorithms are trained and optimized to enable them to better cope with complex situations in actual driving.

In order to reduce costs, Apollo Go has taken a series of measures.In terms of vehicle hardware, the manufacturing cost of vehicles is reduced through technological innovation and large-scale production.In terms of operation costs, Apollo Go improves the operation efficiency of vehicles and reduces operation costs by optimizing the operation management system.Big data analysis and intelligent dispatching algorithms are used to achieve precise vehicle dispatching, reduce empty driving mileage, and improve vehicle utilization.Through cooperation with partners, data and technical resources are shared to reduce data storage and processing costs.

To improve user acceptance, Apollo Go has strengthened safety publicity and user education.Through offline experience activities, online publicity, and other means, users are popularized with the principles, safety, and advantages of driverless technology, improving users' awareness and trust in driverless technology.Users are invited to experience driverless vehicles in person, allowing them to feel the safety and comfort during the actual riding process.

In terms of service quality, Apollo Go continuously optimizes the riding experience of vehicles and improves the smoothness and comfort of vehicle driving.By improving the vehicle's suspension system, seat design, etc., the riding comfort of passengers is enhanced[3]. The construction of the customer service team is strengthened to respond promptly to users' consultations and complaints, solve problems encountered by users during the use process, and improve user satisfaction.

5. Conclusion

Driverless technology, as a revolutionary scientific and technological innovation, is in a stage of rapid development.Through the analysis of the current situation of driverless technology and the case study of Apollo Go, it can be seen that this technology has achieved certain results in both technological research and development and market application, but it also faces many challenges at the same time.In the future, with continuous technological breakthroughs and innovations, driverless technology is expected to bring profound changes to fields such as personal travel and logistics transportation, bringing great convenience to social and economic development and people's lives.

6. Suggestions for the future development of driverless technology

6.1. Technological breakthroughs and innovations

Sensor Technology Upgrades: With the continuous progress of technology, the performance of sensors will be further improved, and the cost will gradually decrease.New sensors such as solid-state lidar are expected to achieve higher resolution and longer detection distances, and have better reliability and stability.At the same time, the trend of sensor integration and miniaturization will make the design of driverless vehicles more compact and flexible.

Optimization of Artificial Intelligence Algorithms: Deep learning algorithms will continue to evolve, improving the accuracy and efficiency of models.The development of quantum computing technology may also bring new opportunities to the driverless field, accelerating the operation speed of complex algorithms and achieving faster and more intelligent decision-making.

6.2. Expansion of the application market

In the future, driverless cars are expected to become one of the mainstream travel modes.With the maturity of technology and the improvement of regulations, driverless taxis and private cars will become more popular. People can travel more easily and freely, using the time for rest, work, or entertainment.The shared travel mode will also be further optimized due to driverless technology, improving resource utilization and reducing travel costs.

In the logistics field, driverless technology will realize a high degree of automation in cargo transportation. Long-distance freight trucks can achieve autonomous driving on highways, reducing labor costs and transportation time.Driverless vehicles will also be widely used in the material handling and sorting links in warehousing and logistics, improving the operation efficiency and accuracy of logistics centers.

6.3. Cultivation of the industrial ecosystem

Strengthen and Deepen Cross-border Cooperation: Automobile manufacturers, technology companies, component suppliers, and travel service platforms should break down industry barriers and deeply integrate[4].Vehicle manufacturers open up platforms and work hand in hand with technology giants to optimize algorithms and upgrade software; component suppliers and vehicle manufacturers jointly research and develop special sensors and wire-controlled chassis to improve system integration; travel platforms provide massive operation scenarios for driverless vehicles and feedback data to drive technological iteration.All parties complement each other's advantages to create a symbiotic and win-win industrial community.

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