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The development and application of autonomous driving technology

Jiaming Liu

Xinjiang Bingtuan No.2 Middle School, 376 Wuxing South Road, Tianshan District, Urumqi City, Xinjiang Uygur Autonomous Region, 830002

L3249016320@outlook.com

Abstract. Autonomous driving technology is emerging as a prominent subject within the realm of modern technology. This technology is increasingly being applied to daily life and is seen as an innovative technology with enormous potential. The application of autonomous driving technology has expanded but still faces issues such as immature technology, incomplete laws, and low user acceptance. The objective of this paper is to comprehensively examine the developmental trajectory, application domains, and obstacles faced by this technology, as well as to anticipate its prospects. To that end, this paper initially provides an overview of the background and relevant concepts pertaining to autonomous driving technology. Subsequently, the developmental history of autonomous driving technology, along with its current application domains, is analyzed. Moreover, the challenges encompassing technical, legal, and ethical aspects of autonomous driving technology are thoroughly explored. Lastly, this paper offers prognostications regarding the future progress of autonomous driving technology, as well as furnishes recommendations for advancing its implementation. It is found that although the research on autonomous driving has been very popular in the past few years, there is still a lack of research on the application and challenges of autonomous driving technology in some fields. Therefore, this paper summarizes the application in different fields, hoping to propose a general direction for the application of autonomous driving in the future.

Keywords: Autonomous vehicles, Motion control, Agriculture, Mining, Construction, Logistics deliver.

1. Introduction

Currently, autonomous driving technology is experiencing continuous development, and self-driving cars have gradually become a reality. However, most of the autonomous driving in various fields has only proposed relevant concept models, but its actual application has not yet been widely used, and the full potential of the technology has not yet been explored [1]. In addition to the significant progress made in the automatic navigation of agricultural machinery, the implementation of other fields is still in its infancy and is not fully utilized due to factors such as algorithms. Many research articles have been published in the academic literature describing the technological advancement of autonomous vehicles (AVs) [2]. However, academic literaltrue outlining the AV Application advantages for different industries is fairly limited, despite a recent prediction suggests that by 2045, AVs would account for up to half of all road travel [3]. Against this backdrop, the purpose of this article is to review the current

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applications of autonomous driving technology and explore its potential advantages in various aspects. In addition, it delves into the current challenges of autonomous driving technology, with a particular focus on technical, legal, and ethical aspects, and what needs to be done for autonomous vehicles to have the desired effect. To achieve this, this study conducted a systematic review of the literature on Avs.

2. The development status of autonomous driving technology

Autonomous driving technology encompasses the utilization of computers, sensors, and related technologies to enable vehicles to navigate and operate independently, without human intervention. By perceiving the surrounding environment, making decisions, and controlling vehicle behavior, it facilitates safe, efficient, and accurate driving.

As stated by the National Highway and Transportation Safety Administration, there exist five tiers of autonomous vehicle (AV) functionality. These tiers are categorized as follows: level 0, which entails no automation; level 1, characterized by the automation of a single control function; level 2, involving the automation of two control functions; level 3, where limited self-driving capabilities are present, but drivers are required to assume control with sufficient notice; level 4, where drivers are not anticipated to assume control at any point during the journey; and level 5, signifying complete self-driving capabilities without human intervention. [4].

The development of autonomous driving can be traced back to the early 20th century. The automotive industry introduced electronic assisted driving systems, such as automatic parking systems and cruise control systems, starting from the 1960s. These systems employed sensors and electronics to assist drivers but still required human control and monitoring. Research on autonomous driving began in the 1980s, with research institutions and automobile manufacturers exploring the use of computers and sensors to sense the environment, make decisions, and control vehicles. In 2004 and 2005, the Defense Advanced Research Projects Agency (DARPA) organized two autonomous vehicle challenges, known as the DARPA Challenge, to foster the development of autonomous driving technology and encourage the creation of vehicles capable of driving autonomously, without human intervention.

From the 2010s onward, several technology companies and automakers commenced commercializing autonomous driving technology. They introduced models that could achieve autonomous driving in specific road environments and gradually improved the technological capabilities. Currently, autonomous driving technology continues to undergo continuous development and enhancement. Automakers and technology companies are investing more in research and development to drive further technological breakthroughs. Concurrently, regions and countries are formulating policies and regulations to create the necessary conditions for the application and promotion of autonomous driving technology [5].

In summary, the progression of autonomous driving technology has evolved from assisted driving to partial autonomous driving, highly automated driving, and eventually to fully autonomous driving. With ongoing technological advancements and increased practical implementation, autonomous driving technology is poised to revolutionize transportation and travel in the future.

3. The application of autonomous driving technology

3.1. Agriculture

The agricultural sector plays a vital role in ensuring human existence, facing numerous obstacles including population expansion, rising energy requirements, and climate change. The advancement of agriculture is essential for enhancing productivity and addressing future challenges. In this context, harnessing technological capabilities becomes imperative to fulfill the nutritional requirements of the global population in an environmentally sustainable and efficient manner.

The application of autonomous driving technology in the agricultural field is mainly reflected in the following aspects.

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Automated farming: Autonomous driving technology can realize automated farming and improve farming efficiency by intelligently controlling agricultural machinery.

Precise fertilization: Autonomous driving technology can intelligently control agricultural machinery to achieve precise fertilization and improve fertilization effect.

Crop monitoring: Autonomous technology can improve farmers' monitoring and management of crops by monitoring crops in real-time in the field.

Energy conservation and environmental protection: Autonomous driving technology can reduce energy consumption and environmental impact by intelligently controlling parameters such as agricultural machinery [6].

The abundance of research on sustainable agriculture highlights the potential of technological integration and eco-friendly solutions in fostering resilient agricultural practices. Developed nations have already embraced mechanization and computerization in their agricultural production processes. However, the absence of digitization and intelligent systems poses a substantial hindrance to further enhancing automation capabilities [6].

At present, many agricultural enterprises around the world have begun to adopt autonomous driving technology for agricultural operations, such as John Deere and Cummins. These companies have applied autonomous driving technology to agricultural operations, and achieved remarkable results, improved agricultural production efficiency, and reduced production costs. Although the application of autonomous driving technology in the agricultural field is still in its infancy, with the continuous development of technology and the continuous reduction of cost, its application prospects will become more and more broad.

3.2. Construction

The construction industry has a significant impact on people's lives, but it faces challenges such as labor shortages, high costs, environmental pollution, and issues with construction quality and safety. Labor shortages and high costs may lead to delays or cancellations of construction projects, affecting employment opportunities and economic growth. Environmental impacts exacerbate climate change and resource scarcity, posing challenges to human survival and sustainable development. Meanwhile, construction quality and safety issues may pose potential risks to people's lives and property. Therefore, addressing these problems is crucial for the construction industry and people's well-being. The application of autonomous driving technology can improve efficiency, reduce risks, address labor shortages, and facilitate data collection, playing an important role in solving some problems in construction scenarios.

The application of autonomous driving technology in the field of building construction is mainly reflected in the following aspects。

Automated construction: Autonomous driving technology can realize automatic construction and improve construction efficiency by intelligently controlling construction machinery and equipment.

Transportation of building materials: Autonomous driving technology can realize the automatic transportation of building materials and reduce transportation costs by intelligently controlling transportation vehicles.

Safety monitoring: Autonomous driving technology can avoid casualties and material losses by monitoring the situation on construction sites in real time.

Energy conservation and environmental protection: Autonomous driving technology can reduce energy consumption and reduce environmental impact by intelligently controlling parameters such as construction machinery and equipment and transportation vehicles.

At present, some construction companies around the world have begun to use autonomous driving technology for building construction operations, such as China State Construction Group and Japan's Daelim Group. These companies have used autonomous driving technology for building construction operations, achieving significant results, improving construction efficiency, and reducing casualties and operating costs.

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3.3. Mining

Mining plays a significant role in economic development, energy and raw material supply, technological innovation, and job creation. However, the mining industry also faces challenges such as safety risks, environmental pollution, and high labor costs. Autonomous driving technology can help address these challenges to a certain extent in the mining sector.

The application of autonomous driving technology in the mining field is mainly reflected in the following aspects.

Reduced casualties: Mining operations often involve large machinery and dangerous goods, and the use of autonomous driving technology can reduce human involvement, thereby reducing the casualty rate.

Improve mining efficiency: Autonomous driving technology can optimize mining operations and improve mining efficiency by intelligently controlling the path and speed of vehicles.

Reduce energy consumption: Autonomous driving technology can reduce energy consumption and reduce environmental impact by intelligently controlling vehicle speed, acceleration, and other parameters.

Lower operating costs: Autonomous driving technology can reduce operating costs by reducing human resources and equipment consumption.

At present, some mining companies around the world have begun to use autonomous driving technology for mining operations, such as Australia's Fortescue Metals Group, Brazil's Vale, Canada's Teck Resources, and so on.

Further development and improvement of autonomous driving technology are needed, along with a combination of traditional human and machinery operations, to better promote the modernization and intelligent development of the mining industry.

3.4. Logistics

In the present era, the realm of logistics has expanded to encompass not only the transportation of goods between companies but also the internal movement of materials, their storage, and loading processes. The key of autonomous driving technology in logistics distribution include the following aspects.

Automated distribution: Autonomous driving technology enables automated distribution by intelligently controlling delivery vehicles, leading to improved efficiency in the distribution process.

Cargo transportation: Autonomous driving technology facilitates the automatic transportation of goods by intelligently controlling transportation vehicles, thereby reducing transportation costs.

Safety monitoring: Real-time monitoring of the status of delivery vehicles using autonomous driving technology helps mitigate the risk of traffic accidents.

Energy conservation and environmental protection: By intelligently controlling parameters such as delivery vehicles, autonomous driving technology contributes to energy conservation and reduced environmental impact.

The logistics industry has successfully integrated autonomous vehicles into its daily operations, providing support to the workforce. Self-driving vehicles are utilized for short distances and in closed areas, while self-driving trucks are employed for long-haul transportation outside of factory premises. Numerous logistics companies worldwide have adopted self-driving technology for vehicles within warehouse facilities. Technological advancements have also automated material handling tasks through the use of transport equipment. It can be argued that machines exhibit superior cost-effectiveness and precision compared to human counterparts in performing these activities.

3.5. Urban planning

Autonomous technology brings many benefits to urban planning, including.

Intelligent traffic control: Autonomous driving technology enables intelligent traffic control by intelligently controlling traffic lights, and monitoring road conditions, and other equipment. This enhances traffic safety and efficiency in urban areas.

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Smart parking: Autonomous driving technology facilitates intelligent parking by intelligently controlling parking lot equipment, addressing urban parking challenges.

Connected Vehicle Services: Autonomous driving technology improves urban traffic efficiency by providing real-time road condition information and navigation services through Internet of Vehicles (IoV) services.

Energy saving and environmental protection: Autonomous driving technology contributes to energy conservation and environmental protection by intelligently controlling vehicles and other parameters.

Currently, some cities worldwide have begun adopting autonomous driving technology for urban transportation planning. Examples include Singapore and Dubai. These cities have used autonomous driving technology in their urban transportation planning, resulting in significant outcomes, such as improved traffic safety and efficiency, and reduced urban air pollution. However, the application of autonomous driving technology in urban planning is not yet very high.

3.6. Tourism

The advancement of automation has the potential to introduce innovative autonomous vehicle (AV) services in the tourism sector. In situations where AVs are not feasible in the destination being visited, there may still be a requirement for conventional human-driven vehicles. Conversely, the opportunity to experience and test self-driving cars at SAE Level 4-5 in locations where such technology is not yet prevalent can also serve as a unique travel motivation [7].

The application of autonomous driving technology in tourism includes the following aspects.

Autonomous tourist vehicles: Autonomous driving technology intelligently controls tourist vehicles, enabling features such as automated navigation and automated driving, enhancing the overall travel experience.

Intelligent tour service: Autonomous driving technology provides intelligent tour services through on-board equipment, offering tourists more convenient and personalized travel experiences.

Currently, many countries and regions across the world have embraced autonomous driving technology for sightseeing, including the United States, Japan, Singapore, and more. These destinations have incorporated autonomous driving technology into their sightseeing and tourism offerings, achieving noteworthy outcomes such as improved travel experiences and reduced travel costs.

However, due to the low psychological acceptance of customers and insufficient technological maturity, this technology has not been widely applied to the tourism field [8].

4. The challenges of autonomous driving technology

Indeed, the development and application of autonomous driving technology encounter various challenges, encompassing technical, legal, and user-related aspects.

Technical difficulties are a prominent challenge in advancing autonomous driving technology. Autonomous vehicles must be capable of operating in diverse road environments and weather conditions, necessitating highly precise sensors and algorithms. Additionally, they must accurately recognize and adapt to the behaviors of other vehicles and pedestrians to ensure safe driving. In pedestrian detection, no real-world experimentation is done to test the proposed methods' ability to classify objects in real-time. The presence of obstacles can occasionally lead to discrepancies between a pedestrian's orientation and the image mask, resulting in orientation estimation errors. Consequently, no algorithm can claim complete accuracy and speed in pedestrian detection, particularly in low-light conditions. The prediction of pedestrian behavior is often overlooked in this context. When it comes to trajectory planning, many studies focused on trajectory detection lack real-world demonstrations and rely solely on simulations or propose solutions using deep learning algorithms. In terms of motion control, the Model Predictive Control algorithm is commonly employed for lateral motion control. However, it has limited fault detection capabilities, and uncertainties that do not align with given conditions are not effectively addressed [9]. These complex technologies require ongoing research and improvement for the widespread commercialization of autonomous driving technology.

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The formulation of laws and regulations poses another challenge for autonomous driving technology. The technology raises numerous legal and ethical concerns, including the allocation of responsibilities, privacy protection, and data security. Legal and regulatory frameworks may differ across countries and regions, hindering the commercialization of autonomous driving technology. Establishing a globally harmonized legal and regulatory framework is indispensable to facilitate the development and application of autonomous driving technology.

User acceptance and psychological barriers represent a significant challenge as well. Acceptance and trust in autonomous vehicles require overcoming psychological barriers and ensuring public confidence in their safety and reliability. Addressing concerns such as the loss of human control and potential accidents is essential to enhance user acceptance [10].

Efforts in research, technology development, collaboration among stakeholders, and public awareness and education are crucial to overcoming these challenges and promoting the successful development and widespread application of autonomous driving technology.

5. The future development of autonomous driving technology

There are abundant opportunities for the advancement of autonomous driving technology, which can be primarily characterized by technological breakthroughs, innovations, the enhancement of laws and regulations, and the augmentation of user acceptance.

From a technical perspective, remarkable strides have been made in autonomous driving technology, encompassing sensors, computer vision, deep learning, artificial intelligence, and other domains. The relentless innovation and breakthroughs in these technologies have enabled autonomous driving to perceive the road environment more accurately, better identify and predict the behavior of other vehicles and pedestrians, thus augmenting the safety and reliability of autonomous vehicles.

Currently, the legal frameworks and regulations pertaining to autonomous driving technology in different countries are still imperfect, giving rise to numerous issues. For instance, challenges persist in determining liability and safeguarding user privacy. In addition to liability insurance and personal privacy issues, autonomous driving technology needs to address the issue of inadequate road infrastructure, such as signage and road markings. Additionally, autonomous driving technology needs to solve the problem of vehicle-to-vehicle communication and how to share the road with non-autonomous vehicles. Furthermore, in the development of autonomous driving technology, it is necessary to consider how to balance technological development and social impact. Hence, the establishment of a globally harmonized legal and regulatory framework is of utmost importance in catalyzing the development and application of autonomous driving technology.

Lastly, the lack of trust and acceptance is a major roadblock to autonomous driving and vehicles. More involvement by governments and automakers is needed to increase consumer trust. In order to establish consumer trust, it is imperative to incorporate transparency as a Non-functional Requirement in the development of self-driving cars. This entails providing consumers with a clear understanding of the potential risks associated with this unproven technology and the potential broader implications it may have. Gaining insight into the factors that contribute to the acceptance of autonomous vehicles is crucial for driving future improvements and advancements [9].

6. Conclusion

This paper summarizes the trajectory, application areas, and obstacles faced by the automatic driving technology, and predicts its prospects. Autonomous driving technology can be applied in a wide range of fields, including agriculture, building construction, mining, logistics, urban planning, tourism, and other fields. The effect it can exert is also remarkable. With the assistance of artificial intelligence, self-driving cars and driving systems have the potential to revolutionize the industry and propel it into a new era of rapid development. However, there are certain limitations to the widespread application of this technology. Currently, self-driving cars are being used in some areas, but their applications in other fields are limited to specific countries or enterprises. The scope of application is not extensive enough, resulting in insufficient effectiveness. The main reason for this is the lack of effective support from key

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technologies in different professional fields, as well as the imperfections in laws and regulations. These imperfections make it difficult to accurately determine responsibility allocation, provide adequate privacy protection and data security, and create a favorable business environment for autonomous driving technology. Therefore, research-oriented enterprises should actively pursue scientific breakthroughs in the field of autonomous driving and strive for innovation. Additionally, the government should enact reasonable legislation to provide legal protection for autonomous driving technology as soon as possible and encourage its development and application. Lastly, society should engage in extensive information and education campaigns to ensure a gradual increase in user acceptance.

References

[1] Bathla, G., Bhadane, K., Singh, R. K., et al. (2022). Autonomous vehicles and intelligent automation: Applications, challenges, and opportunities. Mobile Information Systems, 2022.

[2] Denaro, R. P., Zmud, J. O. H. A. N. N. A., Shladover, S., et al. (2014). Automated vehicle technology. King Coal Highway, 292, 19-24.

[3] Bansal, P., & Kockelman, K. M. (2017). Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. Transportation Research Part A: Policy and Practice, 95, 49-63.

[4] Faisal, A., Kamruzzaman, M., Yigitcanlar, T., & Currie, G. (2019). Understanding autonomous vehicles. Journal of transport and land use, 12(1), 45-72.

[5] Anderson, J. M., Kalra, N., Stanley, K. D., et al. (2014). Brief History and Current State of Autonomous Vehicles. In Autonomous Vehicle Technology: A Guide for Policymakers (pp. 55–74). RAND Corporation.

[6] Ghobadpour, A., Monsalve, G., Cardenas, A., & Mousazadeh, H. (2022). Off-Road Electric Vehicles and Autonomous Robots in Agricultural Sector: Trends, Challenges, and Opportunities. Vehicles, 4(3), 843–864.

[7] Miskolczi, M., Kokeny, L., Asvanyi, K., et al. (2021). Impacts and potential of autonomous vehicles in tourism. The Central European Journal of Regional Development and Tourism, 13(2): 34-51.

[8] Cohen, S. A., & Hopkins, D. (2019). Autonomous vehicles and the future of urban tourism. Annals of tourism research, 74, 33-42.

[9] Parekh, D., Poddar, N., Rajpurkar, A., et al. (2022). A review on autonomous vehicles: Progress, methods and challenges. Electronics, 11(14), 2162.

[10] Othman, K. (2022). Exploring the implications of autonomous vehicles: A comprehensive review. Innovative Infrastructure Solutions, 7(2), 165.