APPLICATION STATUS ANALYSIS OF AUTONOMOUS VEHICLE (AV) TRANSPORT SYSTEMS

L CAI

College of Transportation Engineering, Chang'an University, PO Box 710064, Xi'an Shaanxi, China; Tel: (+86) 18710959897; Email: 2019121239@chd.edu.cn
Prof. Jianjun Wang, Supervisor, College of Transportation Engineering, Chang'an University, PO Box 710064, Xi'an, Shaanxi, China

ABSTRACT

With the rapid popularization of high-tech artificial intelligence, 5G, and cloud computing, public transportation has gradually realized the need for transformation from artificial to autonomous. This paper discusses the development status of autonomous public transport and analyses the shortcomings of this model from the perspective of the vehicle, the public, and government and manufacturers. Finally, based on the case of Shanghai Rail Transit Line 10, the changes brought by the application of autonomous technology in this line is analysed, the advantages of the autonomous vehicle transport system are summarised, and some ideas for the further improvement of autonomous public transportation application and the construction of intelligent transportation is provided.

1. INTRODUCTION

The development of big data, mobile communication, electric transportation, and Mobility as a Service (MaaS) have injected new energy into the development of urban transportation (Cui Hongjun et al, 2020). "Made in China 2025" points out that "intelligence" is one of the focal points of China's economic development in the future. In this context, autonomous public transport emerges as a potential solution.

The application of autonomous public transport is mainly concentrated on buses and rail subways. Developed countries such as Europe and the United States started earlier with this application. In 2015, CityMobil2, a European autonomous bus project, was put into operation in Greece for one year. In March 2018, the first unmanned bus test was launched in San Ramon, California. In December 2017, China's first public road autonomous bus was successfully put into operation on the open road of the Shenzhen Futian Free Trade Zone, indicating that China's intelligent driving technology has accelerated into a "new era" of commercial development. For autonomous rail transit, the North-East MRT line of Singapore built in 2002 is the world's first high-speed subway line with underground, automatic control, and unmanned driving. The M2 line in Lausanne, Switzerland, and the Nuremberg Metro in Germany were put into operation in 2008. Since the beginning of the 21st century, Shanghai Metro Line 10, Guangzhou Zhujiang New Town MRT line, and Beijing Metro Yanfang line have been put into operation. As of 2017, 53 fully automatic subway lines have been put into operation in 36 cities around the world, with a total operating mileage of 789 km. According to the World Report on Metro Automation (2018) released by UITP, the mileage of fully automated metro lines will increase to 3800 km by 2028. It can be said that some important concepts of current urban and road construction, such as compact city, public transport oriented urban design, public transport urban area, and car-free urban area are inseparable from unmanned driving and public transportation.

Based on domestic and foreign research, the objective of this paper is to summarise the current situation of autonomous public transport in terms of practical application, impact level, and public feedback. The existing problems of autonomous public transportation from the aspects of public transportation, and government manufacturers, and points out the future development direction. Finally, taking Shanghai Metro Line 10 as an example, this paper expounds on the changes before and after the application of autonomous technology and summarizes the advantages and importance of it.

2. LITERATURE REVIEW

2.1 Practical Implementation

From the perspective of transportation cost, Bosch (2018) studied the cost of the autonomous bus and the autonomous vehicle from the perspective of the supplier, the government and the passengers. Based on the actual situation after the opening of Shanghai Rail Transit Line 10, Zheng (2017) put forward a more efficient operating scheme for autonomous transport of three aspects, namely operation guarantee specialization, service standardization, and management standardization.

2.2 Social Impact

By summarizing the workshop organized by the European project CityMobil2, Sessa et al. (2016) found that compared to human driving, autonomous buses will result in less likelihood of exceeding the speed limit, less likelihood of excessive accelerations and decelerations, and in reduced fuel consumption and pollutant emissions. From the perspective of daily travel, Liu and Schonfeld (2020) studied the impact of autonomous buses on travel cost and travel time. Lopez-Lambas and Alonso (2019) used the focus groups (FGS) method to analyze the impact of the implementation of autonomous buses. The results show that autonomous buses can detect people and obstacles better, and then avoid accidents caused by human factors. Cui Hongjun et al. (2020) pointed out that we should focus on the impact of autonomous buses on urban construction and lifestyle changes.

2.3 Public Feedback

After the completion of the pilot application of the European research project CityMobil2 with autonomous buses in the city of Papadima, Genitsaris et al. (2020) surveyed Greeks about their acceptance of autonomous buses by handing out questionnaires. The results showed that most respondents supported the operation of autonomous buses in the city center. Based on a survey of 1,419 members of the Norwegian Automobile Federation, Roche-Cerasi (2019) found that a positive attitude does not imply that people will be willing to use autonomous buses. Only 6.1% perceived that autonomous buses was the best option. About 52.5% of the sample were more worried about traffic safety, while 54.0% were more concerned about security related to violence and data privacy. Salonen (2018) studied the difference in user experience between autonomous buses and traditional buses by using the feedback data of 197 people who had used autonomous buses in Finland. The results show that autonomous buses are safer than traditional buses, but compared with traffic safety, the sense of safety of passengers deserves more attention.

3. PROBLEMS

3.1 Autonomous Bus

Compared with traditional buses, autonomous buses not only has high cost but also has high requirements for infrastructure, which makes infrastructure construction difficult and expensive. Also, the current application of autonomous buses is mainly concentrated in the suburbs, universities, and other areas with light traffic flow, but it has not fully adapted to the urban centers with congestion. In addition, the safety of autonomous buses needs to be improved. The traffic research center of the University of Michigan reported that the accident rate of unmanned driving was more than double that of manned driving. After that, the Virginia Tech Transportation Institute conducted a further study and found that the incidence of minor accidents without driving was lower than that of manned driving, but the reduction in the incidence of serious accidents was not evident.

3.2 Public

Regarding the full implementation of autonomous buses, most people are not optimistic about it. People worry that autonomous buses are not as good as traditional buses in protecting passengers' privacy and personal safety. At the same time, the presence of the driver on the vehicle will make passengers feel more at ease. This series of reasons lead to the general public's distrust of autonomous vehicle transport system, and also increase the difficulty of the application of the technology to a certain extent.

3.3 Government and Manufacturers

At present, with the development of artificial intelligence, Google, Uber and other traditional car manufacturers have begun to carry out research on autonomous technology. However, because the return on investment of public transport is far lower than that of private cars, the focus of technology giants is on the latter. Therefore, the government should take the lead in realizing autonomous vehicle transport system. However, due to the difficulty of public transportation management brought by the openness of public transportation lines, the large-scale use of unmanned public transportation is still far away.

4. FUTURE DEVELOPMENTS

4.1 Upgrading of Hardware and Software Equipment

According to the National Road Traffic Safety Administration of the United States, 95% of accidents are caused by driver error, and autonomous driving can greatly reduce traffic accidents. However, as far as the current application of autonomous lines, the accident rate of autonomous buses is higher than that of the normal bus. Therefore, the sensor, camera, and other hardware equipment need to be upgraded, and the model algorithm needs to be continuously optimized.

4.2 The Government Should Strengthen Communication

From the public feedback, people look forward to the arrival of autonomous buses but worry about its operational safety, data privacy security, and passenger safety. To a certain extent, this is caused by the lack of public awareness of autonomous vehicle transport systems. Therefore, the government can publicize autonomous traffic through public media such as television and the Internet, so as to enhance the respect by citizens for autonomous vehicle transport systems.

4.3 Connection of Autonomous Public Transport Network

Nowadays, there is a lack of connection between various modes of autonomous public transport. R & D units, manufacturers, government departments and transportation departments are developing their own systems. This phenomenon leads to the inefficient transportation on the whole system. Therefore, in the future development of autonomous public transport, stakeholders should pay attention to linking real networks and the interconnection of network data.

5. CASE STUDY

5.1 Overview of Shanghai Metro Line 10

Shanghai Metro Line 10 has a total length of 36 km and 31 stations. It was put into operation on April 10, 2010. In the initial stage of operation, line 10 was still manually operated. It was not until August 9, 2014 that the fully automatic and unmanned operation mode was officially launched. This line is also the first autonomous metro line with the highest automation level (GoA4) in China (Deng, Lu et al. 2015).

5.2 The "9.27" Accident

At 14:37 on September 27, 2011, there was a rear end collision between trains 1005 and 1016 on Metro Line 10 between the Yuyuan station and the Laoximen station. A total of 271 passengers were injured. On the day of the incident, the signal at Xintiandi Station was faulty, and the line was manually operated. When the traffic controller issued the order of telephone blocking in violation of the regulations, the operator on duty at the receiving station agreed to the telephone blocking requirements of the departure station without strictly confirming whether the section line was free, resulting in the rear end collision between 1005 train and 1016 train. It was confirmed that the manual scheduling of trains was the direct cause of the rear end collision accident. After the line implemented the automatic system, the position of all trains in the subway line were displayed in real-time, and the scheduling of trains changed from manual scheduling to computer automatic scheduling, which greatly reduces the possibility of human error.

5.3 Advantages of Autonomous Operation

For Shanghai Metro Line 10, since the adoption of the fully automatic driving technology (GoA4 level: unmanned driving), it has realised the following advantages:

1) The punctuality of line 10 is more than 99.9%, and the delay time is less than 5 minutes.
2) After the implementation of automatic driving technology, the average travel speed of vehicles increased by 2.73 km / h, the average warehousing time decreased by 130 seconds, and the station platform parking time shortened by 10 seconds.
3) The cost of line operation and maintenance has been greatly reduced, and the operational efficiency has been significantly improved.
4) Line 10 innovatively realizes a new mode of integration of operation, management and maintenance, which greatly improves the safety of train operation.

6. CONCLUSIONS

The continuous development of Internet, 5G, cloud computing and other technologies, the theory and technology of autonomous public transport are constantly improved. Intelligent transportation is the core of the future development of China's transportation. Traffic intelligence can effectively alleviate traffic congestion, improve traffic efficiency, reduce traffic accidents, and make vehicles run more smoothly. Under the background of the current era, how to apply autonomous public transport to real life, solve the lack of infrastructure, the people's concerns, and the reliability of autonomous public transport in the face of complex environment is the top priority of future research.

7. REFERENCES

Boesch, PM, Becker, F, Becker, H & Axhausen, KW, 2018. Cost-based analysis of autonomous mobility services. Transport Policy, 64:76-91.

Cui Hongjun, Yang Yizhe and Zhu Minqing, J, 2020. Summary of dispatching technology for shared driverless transportation system. *Chinese Journal of Highway and Transport*, 33(5):44-54.

Deng, XQ, Lu, Z, Bai, B & Gao, DH, 2015. Research on the Formation Mechanism of Metro Emergency: A Case Study of Rear-End Accident on Shanghai Subway Line 10. Proceedings of the Ninth International Conference on Management Science and Engineering Management, 362:1487-1499.

Lopez-Lambas, ME & Alonso, A, 2019. The Driverless Bus: An Analysis of Public Perceptions and Acceptability. Sustainability, 11(18).

Liu, S & Schonfeld, PM, 2020. Effects of Driverless Vehicles on Competitiveness of Bus Transit Services. Journal of Transportation Engineering Part A - Systems, 146(4).

Papadima, G, Genitsaris, E, Karagiotas, I, Naniopoulos, A & Nalmpantis, D, 2020. Investigation of acceptance of driverless buses in the city of Trikala and optimization of the service using Conjoint Analysis. Utilities Policy, 62.

Roche-Cerasi, I, 2019. Public acceptance of driverless shuttles in Norway. Transportation Research Part F-Traffic Psychology and Behaviour, 66:162-183.

Salonen, AO, 2018. Passenger's subjective traffic safety, in-vehicle security and emergency management in the driverless shuttle bus in Finland. Transport Policy, 61:106-110.

Sessa, C, Alessandrini, A, Flament, M, Hoadley, S, Pietroni, F & Stam, D, 2016. The Socio-Economic Impact of Urban Road Automation Scenarios: CityMobil2 Participatory Appraisal Exercise. Road Vehicle Automation 3. G. Meyer and S. Beiker: 163-186.

Zheng Wei, 2017. System function and scenario analysis under fully automatic unmanned driving mode. Urban Rail Transit Research, 20(11):107-109 & 136.