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Analysis of Real-Time Road Conditions and Congestion Control Effectiveness in Guangzhou Under the Environment of Internet of Vehicles

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Abstract. In order to help Guangzhou solve the problem of highway traffic congestion, this paper investigates the real-time road conditions of highway traffic in Guangzhou in October 2017, September 2019 and May 2021 with the help of "Internet of vehicles" technology, and uses GIS technology combined with survey data to map the changes of highway traffic congestion in Guangzhou. At the same time, it also summarizes the new traffic congestion sections, the sections with the fastest increase in traffic congestion and the sections with improved traffic congestion in Guangzhou from 2017 to 2021. By further analyzing the reasons for the improvement of traffic congestion, this paper obtains the countermeasures that really take effect in the work of traffic congestion control in Guangzhou, and further puts forward some suggestions for traffic congestion control in Guangzhou.

Keywords. Urban traffic, real-time road conditions, Internet of vehicles, GIS, Guangzhou

1. Introduction

Traffic system is a very complex system. It is difficult to fundamentally solve the problem from the perspective of vehicles or roads alone. The Internet of vehicles (IOV) proposed in 2005 is a very important application field and development direction [1-5]. Internet of vehicles (IOV) is a huge interactive network composed of vehicle location, speed, route and other information. With the help of Internet of vehicles technology, it can comprehensively collect urban traffic congestion data to analyze the details of urban traffic congestion and provide a strong demonstration for the city to solve the problem of traffic congestion.

Guangdong Province is the province with the largest economic aggregate in China. As the capital city of Guangdong Province, Guangzhou is not only the political, economic and cultural center of Guangdong Province, but also a partner in close contact with Hong Kong and Macao, but also the largest foreign trade and transportation hub in South China [6]. The total area of the city under Guangzhou's jurisdiction is 7434.4 square kilometers. The overall planning areas at the municipal

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level are Yuexiu, Haizhu, Liwan, Tianhe, Baiyun, Huangpu and Nansha, referred to as "Ancient seven districts". After the adjustment of administrative divisions, Guangzhou governs 11 districts [7] (figure 1) including Yuexiu, Haizhu, Liwan, Tianhe, Baiyun, Huangpu, Huadu, Panyu, Nansha, Conghua and Zengcheng. With its own geographical advantages, Guangzhou's economy and society have developed rapidly. However, it has a considerable impact on urban traffic. The problem of traffic congestion has become the bottleneck of Guangzhou's sustainable economic and social development.

Figure 1. Administrative division map of Guangzhou.

2. Change of Traffic Congestion Ranking in Guangzhou

According to the traffic analysis report of major cities in China, the ranking of Guangzhou in the peak congestion index of major cities in China fluctuates. In 2019, Gaode initiated the comprehensive evaluation of urban traffic disease diagnosis "traffic health index" to comprehensively describe the urban traffic operation. The higher the "traffic health index" is, the closer it is to the ideal value and the healthier the urban operation is. The lower the index is, the farther it is from the ideal value and the more unhealthy it is. The health level is 71.48% [8]. The "traffic health index" of Guangzhou is shown in table 1. In the first quarter of 2019 and 2021 (due to the return of a large number of migrant workers due to the Spring Festival transportation), the traffic health index of Guangzhou was the best, and the sub-health ranking did not rank in the top 10 in China, but the traffic health index of Guangzhou ranked in the top 5 in the second, third and fourth quarters. Despite novel coronavirus pneumonia, the traffic health index increased in 2020, but ranked fifth in the first quarter of the year. On the whole, the traffic in Guangzhou is still in a sub-health state, and there is no trend to get better.

2.1. Survey Data of Traffic Congestion in Guangzhou

Although the Guangzhou municipal government is also actively controlling the traffic congestion in Guangzhou, there are still some problems, resulting in unstable results. Traffic congestion not only brings inconvenience to citizens, but also increases the management cost of the city. China's city novel coronavirus pneumonia affected the average monthly cost of congestion in Guangzhou in the first quarter of 2020, which was 23.9% lower than that in the first quarter of 2019, but still amounted to 600 Yuan, according to a traffic analysis report of major cities in China. There are obvious differences in traffic congestion among districts in Guangzhou. Generally, the congestion degree in the core area is higher than that in other districts. In order to understand the road conditions in Guangzhou, this paper investigates and analyzes the real-time road conditions in key areas of Guangzhou.

Table 1. Changes of "Traffic health index" in Guangzhou.

Time interval	Traffic health index	Traffic health index sub-health ranking
First quarter of 2019	63.21%	11
Second quarter of 2019	51.83%	1
Third quarter of 2019	44.88%	2
Fourth quarter of 2019	51.20%	3
First quarter of 2020	65.06%	5
Second quarter of 2020	48.79%	4
Third quarter of 2020	48.15%	3
Fourth quarter of 2020	53.83%	3
First quarter of 2021	59.05%	11
Third quarter of 2021	51.28%	4
Fourth quarter of 2021	53.39%	4

Note: The data comes from the traffic analysis report of major cities in China

2.2. Real Time Traffic Congestion Index Data of Guangzhou

Taking the real-time updated traffic status on Guangzhou traffic information network as the data source (updated every 5 minutes), this paper collects and arranges tens of thousands of traffic information data in October 2017 (October 18-october 29, 07:00-23:00), September 2019 (September 18-september 29, 07:00-23:00) and may 2021 (May 18-May 29, 07:00-23:00), which are very detailed, including traffic index Congestion level, average speed, etc.

2.3. Introduction to Traffic Congestion Index

The current "traffic congestion index" divides the regional road traffic status into five levels: smooth, basically smooth, mild congestion, moderate congestion and severe congestion. As shown in table 2, the congestion index between 0 and 2 is "unblocked", between 2 and 4 is "basically unblocked", between 4 and 6 is "mild congestion",

between 6 and 8 is "moderate congestion", and between 8 and 10 is "severe congestion" [9-10].

Table 2. Classification list of traffic congestion index.

Traffic index	Corresponding road conditions	Travel time
0-2(unblocked)	Basically no road congestion	You can drive according to the road speed limit standard
2-4(basically unblocked)	There is a small amount of road congestion	It takes 0.2-0.5 times more time than when it is unblocked
4-6(mild congestion)	Some ring roads and trunk roads are congested	It takes 0.5-0.8 times more time than when it is unblocked
6-8(moderate congestion)	A large number of ring roads and trunk roads are congested	It takes0.8-1.1 times more time than when it is unblocked
8-10(severe congestion)	Most roads in the city are congested	It takes more than 1.1 times longer than when it is unblocked

2.4. Data Processing

This paper use AICGIS software to cut out and project the key areas of traffic congestion in the central urban area of Guangzhou from the vector map of China, and use UTM projection WGS84 coordinate system. Process and analyze tens of thousands of traffic information data of the whole month in 2017, 2019 and 2021, extract the congestion level information, count the number of "serious congestion" in the key areas of traffic congestion in the central urban area of Guangzhou, rank them according to the number of "serious congestion" from more to less, and give them a progressive color from deep to light, so as to make the traffic congestion change map of the key areas of traffic congestion in the central urban area of Guangzhou.

3. Traffic and Road Conditions in Key Areas of Guangzhou

According to the division standard of key traffic congestion areas of Guangzhou Municipal Transportation Commission, there are 21 key traffic congestion areas in Guangzhou, including Tianhe business district, Changgang, Chepeiyuan village, Yanling Shashan, Dongshan, Zhujiang New Town, Zhoumen Xiguan, Zhongda, Huanshi Dongshahe, Haizhu Square Gongyuqnqian, Xiaobeilu lake, Liuhua, Baiyun New Town, Pazhou, Zengcha tongdewei, Dashadi, Chigang, Shiliugang, University City, Nanzhou and Fangcun (as shown in figure 2).

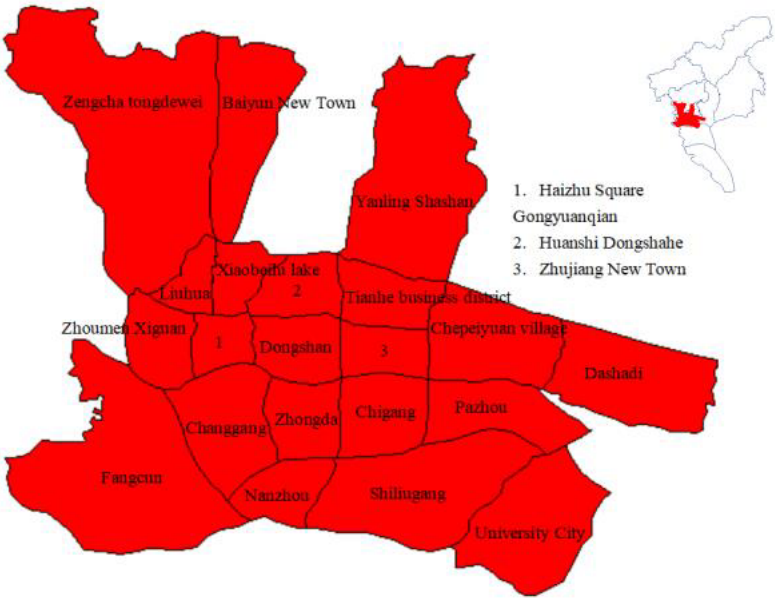

Figure 2. Key traffic areas in Guangzhou.

By analyzing the real-time road conditions of 21 key areas in Guangzhou, it is found that among the 21 key areas in 2017, only Changgang (6 times), Tianhe business district (5 times) and Yanling Shashan (5 times) had "serious congestion" more than or equal to 5 times, and most areas would not have "serious congestion" (as shown in table 3). However, by 2019, the number of serious congestion in 21 key areas greater than or equal to 5 increased to 13, and the Tianhe business district reached 35; In 2021, there were still 13 areas with severe congestion times greater than or equal to 5 in 21 key areas, but the maximum number reached 78 (Tianhe business district), and the number doubled. Although the congestion in some areas has eased and the traffic congestion ranking in Guangzhou has not changed significantly, the actual congestion is more serious (as shown in figure 3).

From the time point of view, the current traffic congestion in Guangzhou began to appear around 7:30 a.m. and almost disappeared after 22:00. There is an "early peak" phenomenon from 7:30 a.m. to 9:30 a.m. and a "late peak" phenomenon from 16:30 p.m. to 19:30 p.m., and the late peak is significantly higher than the early peak. The congestion in Guangzhou began to worsen in the afternoon and didn't dissipate until 11 pm.

Table 3. Changes in the number of "severe congestion" in 21 key areas of Guangzhou frequency.

Key areas	October 2017	September 2019	May 2021	Key areas	October 2017	September 2019	May 2021
Baiyun New Town	0	6	6	Nanzhou	0	4	4
Changgang	6	20	40	Pazhou	0	1	3
Chepeiyuan village	1	13	16	Shiliugang	0	3	2
Chigang	0	4	11	Tianhe	5	35	78

				business district			
Dashadi	0	2	0	Xiaobeilu lake	0	10	4
University City	0	0	0	Yanling Shashan	5	15	23
Dongshan	1	20	46	Zengcha tongdewei	0	16	5
Fangcun	0	3	1	Zhongda	1	3	2
Haizhu Square Gongyuanqian	0	16	6	Zhoumen Xiguan	1	22	7
Huanshi Dongshahe	0	11	18	Zhujiang New Town	2	25	51
Liuhua	1	30	10				

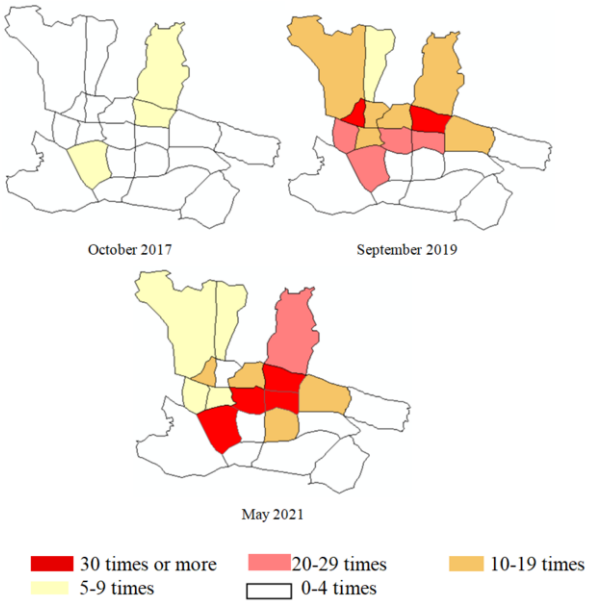

Figure 3. Number of "severe congestion" in 21 key areas of Guangzhou.

4. Traffic Conditions of Key Passages in Guangzhou

In order to better solve the problem of traffic congestion in Guangzhou, this paper investigates 128 key channels in Guangzhou. Through the comparative analysis of the data in October 2017 and May 2021, it is found that among the 128 important channels, 25 had serious congestion in 2017, 32 had congestion in 2021, and some roads doubled the number of congestion. Comparing the ranking data of the number of congestion in key channels in Guangzhou in October 2017 and May 2021, it is found that Tianshou Road (South North), which has the largest number of congestion and ranks first in May 2021, has 67 times of serious congestion. Although the number of severe congestion ranked first in October 2017, it was only 15 times, and the number of severe congestion on the same road increased by 4.5 times in four years. From 2017 to 2021, the roads

with large changes in the ranking list of congestion times of key channels in Guangzhou are shown in table 4.

It can be seen from table 4 that in May 2021, compared with October 2017, the number of severe congestion from none to some roads include Tianhe Road (East West, 10 times), Jianghai Avenue Liede Road (North South, 9 times), Yanling Road (North South, 9 times), Linjiang Avenue (East West, 9 times), Huacheng Avenue (East West, 8 times), Keyun Road (South North, 7 times), Inner loop line A 3(Ring Road, 6 times), Airport Road (South North, 6 times), Renmin Road (North South, 4 times). In May 2021, compared with October 2017, the number of roads with severe congestion doubled. More than three times doubled are Huangpu Avenue West Section (East West, 34 times), TIYU East Road Xiancun Road (North South, 28 times), Huacheng Avenue (West East, 26 times), Tianshou Road (North South, 6.5 times), Tianhe Road (West East, 5.6 times), Airport Road (North South, 5.5 times), Dongfeng Road (West East, 5.3 times), Tianshou Road (South North, 4.5 times), Dongfeng Road (East West, 4.5 times), Zengcha road Qingcha Road (North South, 3.8 times), Guangyuan Expressway (East West, 3.5 times),Inner loop line B 3 (Ring Road, 3.3 times), Jinshazhou Road (West East, 3 times), these are the roads that need to be paid attention to in the later stage.

Table 4. Changes in congestion times of key channels in Guangzhou from October 2017 to May 2021.

Channel name	Direction	Number of severe congestion in 2021	Number of severe congestion in 2017	Multiple
Tianshou Road	South North	67	15	4.5
Zengcha road Qingcha Road	North South	57	15	3.8
Huacheng Avenue	West East	52	2	26
Tianhe Road	West East	39	7	5.6
Jianghai Avenue-Liede Road	South North	35	14	2.5
West section of Huangpu Avenue	East West	34	1	34
Jinshazhou Road	West East	33	11	3
TIYU East Road - Xiancun Road	North South	28	1	28
Guangyuan West Road	North South	25	15	1.7
Airport Road	North South	22	4	5.5
Tianhe North Road	West East	16	2	8
Dongfeng Road	West East	16	3	5.3
Tianshou Road	North South	13	2	6.5
Cangbian road-Xiaobei road-Tongxin Road-Xiatang West-Jingyun Road	North South	10	4	2.5
Inner loop line B 3	Loop Line	10	3	3.3
Guangyuan West Road	South North	10	10	1
Tianhe Road	East West	10	0	∞
Shatai Road	North South	9	4	2.25
Dongfeng Road	East West	9	2	4.5

Jianghai Avenue-Liede Road	North South	9	0	∞
Yanling Road	North South	9	0	∞
Linjiang Avenue	East West	9	0	∞
Huacheng Avenue	East West	8	0	∞
Guangyuan Expressway	East West	7	2	3.5
Keyun Road	South North	7	0	∞
Inner loop line B 2	Loop Line	6	3	2
Inner loop line A 3	Loop Line	6	0	∞
Airport Road	South North	6	0	∞
Renmin Road	North South	4	0	∞
Inner loop line A 1	Loop Line	5	7	0.71
West section of Huangpu Avenue	West East	3	3	1
Sanyuanli Avenue	South North	0	10	0
TIYU East Road - Xiancun Road	South North	0	3	0
Huadi Avenue	South North	1	2	0.5

At the same time, it is also found that the road with improved traffic congestion, such as serious congestion in October 2017, but the roads with serious congestion disappearing in May 2021 include Sanyuanli Avenue (south north, 10 times) and TIYU East Road Xiancun Road (south north, 3 times). The road section with better road control effect is Huadi Avenue (South North). The number of congestion has not increased after 4 years, but has been reduced from 2 to 1. After further investigation, it is found that among the roads showing the improvement of traffic congestion in the doubling of the number of congestion in key channels in Guangzhou from 2017 to 2021, TIYU East Road - Xiancun Road (South North) is affected by objective events, because the construction of subway Xiancun station has closed the South-to-North traffic of Xiancun Road (Huangpu Avenue to Jinsui Road). Only Sanyuanli Avenue (South North) and Huadi Avenue (South North) can really alleviate traffic congestion due to the congestion control policy.

Sanyuanli Avenue was previously a traffic jam black spot. The reason why the congestion situation has improved is mainly affected by the government's plot reconstruction plan. The original plot of Sanyuanli Avenue was mainly used for industrial land and commercial facilities, and the land function was relatively single. In July 2017, the plot of Sanyuanli Avenue began to be transformed, and the original industrial land was adjusted to residential land. A branch road with a width of 15 meters was added on the East and west sides of Sanyuanli Avenue to alleviate the traffic pressure. The improvement of road traffic on Huadi Avenue (South North) is because it was included in the 12 traffic congestion control projects in Guangzhou from 2017 to 2018. In March 2019, Guangzhou traffic police enabled six sets of "intelligent electric police", that is, electronic police capture function, to monitor various behaviors such as driving, using mobile phones, not wearing seat belts and so on.

5. Enlightenment

Guangzhou has made a lot of efforts in urban traffic construction and made some achievements in traffic congestion control [11]. However, through the analysis of the changes in the ranking of traffic congestion in Guangzhou, the traffic conditions in key areas and key channels in Guangzhou, it can be seen that the efficiency and effect of traffic control in Guangzhou are not ideal. Combined with the Internet of vehicles technology, the statistical road congestion data can be analyzed to find some detailed problems in the treatment of traffic congestion in Guangzhou in more detail, analyze the effectiveness of the work done in the early stage, and then put forward some targeted improvement suggestions:

First, we can increase the continuous implementation of policies that have achieved remarkable results in controlling congestion. In the analysis of the doubling of the number of congestion in key channels in Guangzhou from 2017 to 2019, only Sanyuanli Avenue (South North) and Huadi Avenue (South North) can really alleviate traffic congestion due to the congestion control policy. The resulting policies for the effectiveness of congestion control are mainly the government's plot transformation planning, the adjustment of the original industrial land to residential land, and the construction of intelligent transportation system and the use of "intelligent electric police" equipment. Therefore, in the later treatment of road traffic congestion in Guangzhou, we should continue to strengthen the implementation of land transformation and intelligent transportation investment construction, and establish and improve collaborative innovation in the field of urban transportation technology [12]. In terms of plot transformation, industrial land, commercial land, even land for colleges and universities and secondary professional schools in congested sections of the urban area can be transformed to attract the flow of people and vehicles to non urban areas of Guangzhou and reduce the pressure of urban road traffic.

Second, increase scientific and technological investment in urban traffic management. Guangzhou city should continue to increase its investment in science and technology in traffic management, improve traffic information and speed up the construction of intelligent transportation system. Government and enterprises should build a "Internet plus traffic" development ecosystem, and speed up the comprehensive development of smart city. Actively apply "Internet + transportation", such as advocating and promoting parking resource sharing. Compared with charging high parking fees to limit the growth of vehicles [13], the Internet of vehicles has a clearer solution [14]. The transport departments and territorial governments need to further tap the available parking resources, promote the "Internet plus parking" technology application, encourage Internet companies to cooperate with car park operators to promote shared parking, promote the sharing of parking resources at the wrong time, and increase the utilization ratio of parking resources.

Third, priority should be given to improving heavily congested roads. This paper sorts out the ranking of "serious congestion" times of key channels in Guangzhou and the congested sections with doubled times. In the later stage of traffic congestion control, Guangzhou should focus on these special sections, give priority to increasing the scientific and technological investment in traffic management of these sections, and alleviate the congestion of key sections. For the road sections with high growth rate of congestion, timely monitoring and attention shall be paid to slow down the development of congestion. For the posts of fixed Road police and co management personnel in these important sections of the city, improve the control of Road police on

traffic violations through performance assessment [15], and gradually realize zero traffic accidents based on the application of Internet of vehicles technology. Ideally, "zero congestion" and "extreme capacity" can be achieved gradually.

Fourth, develop public transport - build a slow traffic system. Bike sharing has achieved remarkable results in alleviating urban congestion and reducing pollutant emissions [16]. After the introduction of shared bicycles, the degree of congestion in Guangzhou decreased by 6.8%, and the proportion of bicycle travel doubled from 5.5% to 11.6%. The substitution effect of sharing bicycles on private car travel is obvious. Secondly, we should strengthen the supervision and management of shared bicycle parking spots, standardize the parking of shared bicycles by some customers, and place them in the specified area to prevent road occupation. Finally, it is also necessary to increase the protection and maintenance of shared bicycles, reduce the malicious damage of shared bicycles and ensure the normal use of shared bicycles. At the same time, with the help of Internet of vehicles technology, the new car time-sharing rental service mode is realized, and the network construction in Guangzhou is gradually opened up. Establish bus priority system and bus information service system [17], and promote the intelligent safety and service mode of water bus to attract passenger flow. Vigorously publicize the intelligent safety and service mode of Guangzhou water bus on major platforms to attract more passengers to change to the water bus traffic mode and reduce the pressure of highway traffic.

Fifthly, build a stable, scientific and fair evaluation system for blocking treatment. The fatal problem of traffic congestion in Guangzhou is the lack of a stable, scientific and fair evaluation system. For example, there is no stable, scientific and fair evaluation system for license restriction, such as the rise of parking fees, so that the data published by the official tailoring often serve the short-term policy effect. The formulation of transportation policies based on such data is undoubtedly open to discussion. Therefore, the evaluation needs objective and quantifiable specific data, which depends on the specific situation. Relevant departments in Guangzhou need to issue a special and operable evaluation standard system [18] to guide the benign development of the treatment of traffic congestion.

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Reference

[1] Liu NJ. Internet of Vehicle: Your next connection. WinWin, DEC. 2011; (1): 23-28.
[2] Hu LL, LI HF, Xv X, et al. An intelligent vehicle monitoring system based on internet of things. Proceeding of 2011 Seventh International Conference on Computational Intelligence and Security. 2011; p. 231-233.
[3] Wang JQ, Wu CW. Research on architecture and key technologies of Internet of Vehicles. Microcomputer Information. 2011; 27(4): l56-158.
[4] Zhu YM, Li ML, Ni MX. Research on vehicle sensor networks. ZTE Technology. 2009; 15 (5): 28-32.
[5] Wang XJ, Shen HF, Wang L. Research on the development strategy of intelligent transportation system in China. Transportation System Engineering and Information. 2006; 6(4): 9-12.

[6] Ye L. Research on the treatment of traffic congestion in Guangzhou. Lanzhou: Lanzhou University. 2015.
[7] Nanfang Daily. Guangzhou abolished Huangpu Luogang District and established a New Huangpu District.
[8] Gaud Map. 2019 Q1 traffic analysis report of major cities in China.
[9] He LX, Liu C. Relationship between rainfall and traffic congestion index in Guangzhou. Guangdong meteorology. 2018; 40(5): 58-61.
[10] Zhang YY. Research on the attitude and behavior response of the audience to the automobile purchase restriction policy in Guangzhou. Guangzhou: Jinan University. 2017.
[11] Huang X. Research on traffic congestion and governance in Guangzhou. Xi'an: Shanxi Normal University. 2013.
[12] Ding H. Analysis of traffic violation data of urban trunk roads based on data fitting model of information granulation - Taking the central urban area of Nanjing as an example. Science and Technology Management Research. 2018; 10: 227-234.
[13] Zhang XL. Analysis on public acceptance of urban road congestion charging policy. Journal of Wuhan Transportation Vocational College. 2012; (03): 25-27.
[14] Jiang SH. "Internet of vehicles" is a good medicine for traffic congestion. Internet of Things Technology. 2011.
[15] Wu ZJ. Research on comprehensive treatment countermeasures of traffic congestion in Guangzhou. Guangzhou: South China University of Technology. 2016.
[16] Zhang NX. Investigation report on sharing bicycles. Science, Education and Culture Collection (Zhongxunlian Journal). 2018; (12):202-203.
[17] Zhan J. Research on demand responsive public transport operation mode and adaptability in low demand areas. 2016; (04):87.
[18] Chen X. Research on collaborative innovation mechanism in the field of urban transportation technology - Taking the demonstration application development in the field of urban rail transit in Beijing as an example. Research on Science and Technology Management. 2018; 14: 111-116.