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Investigation on the Status Quo of Shared Bicycles in Wenzhou and Analysis of Travel Characteristics

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Abstract: In recent years, shared bicycles have developed rapidly across the country as a convenient new mode of travel. It meets the needs of citizens for short-distance travel and has many advantages such as convenience, high flexibility, and low price. This paper takes the survey results of shared bicycle users in Lucheng District, Wenzhou City and the operation of 181 sites within 20 days as the analysis objects, using data analysis software and other tools to analyze the shape characteristics of shared bicycles, including the number of daily use of a single bicycle, running the busiest site and the idlest site, etc. And through the analysis results, the current service system of shared bicycles is evaluated, and suggestions for improving the efficiency of the bicycle service system are given.

Keywords: Shared bicycles; Data analysis; Feature analysis; Status survey.

1. Introduction

Since the beginning of the 21st century, with the rapid development of society, the rapid development of science and technology, the flow of information, the communication between people has become more and more close, and life has become more and more convenient. Big data is the product of this high-tech era. Big data refers to the rapid acquisition, collection and storage, value extraction, intelligent processing and distribution of a large number of data resources generated by the Internet, mobile Internet, operators and other channels, to be used for information assets such as enterprise decision support. It has four characteristics: massive data scale, fast data flow, diverse data types and low-value density [1].

The strategic significance of big data technology is not only to master massive data information but also to professionally process this meaningful data and discover its value from it. The content of the data is more important than the quantity. At present, big data has been applied in many industries [2]. The Los Angeles Police Department and the University of California collaborated to use big data to predict crime. Google used user search terms to predict the spread of the flu. Statistician Nate Silver uses big data to predict the outcome of the 2012 US election. MIT uses cellphone location data and traffic data to build urban planning. Macy's SAS-based systems price up to 73 million items in real-time based on demand and inventory.

At present, there are many prediction kinds of research on bicycle systems at home and abroad, such as:

Lin J H, Chou T C. et al proposed a practical path distance optimization method for VRP (Vehicle Routing Problem) to accommodate several additional constraints of road problems and also implemented a method that integrates real-time site information, Web GIS, urban road network and PBS A system of combined heuristics. The system includes a simulator that can help managers effectively plan routes, find optimal scheduling strategies, implement hot spot analysis and adjust site deployment strategies, and reduce system operating costs.

Patrick Vogel [3] proposed a design and management method for the balance of station vehicles in PBS operation according to the short-term, medium-term and long-term: soon, rely on system employees to dispatch vehicles, in the medium-term, users are encouraged to balance the station vehicles, and in the long-term, the site location and capacity can be adjusted according to demand. After data cleaning, the influence and time distribution of car rental and car return behaviour on the site were analyzed respectively. Analyze the travel characteristics of various stations in time and space.

Lin Yanping, Dou Wanfeng[4], etc. used the autoregressive quadrature moving average (ARIMA) model to fit and predict the demand time series of bicycles during peak hours, and compared it with the baseline method (Baseline) prediction error. The results show that for the prediction of different site types, the average relative error between the predicted value and the actual value of this model is lower than that of the Baseline prediction method. However, they did not incorporate the influencing factors of user travel characteristics into the ARIMA model, and the prediction accuracy of the ARIMA model is relatively low.

Mao Xiaoyan and Tang Xinyu from Ningbo University analyzed and modelled the number and layout of bicycle stations in response to the increase in the number of bicycle stations in Ningbo, while the increase in new users and the daily turnover rate showed a downward trend. K-means clustering method was used to classify different sites by daily turnover rate. Secondly, the deficiencies of the prediction model of the number of stations based on area and service population in Ningbo's urban public bicycle special planning are discussed. Finally, based on the relatively mature urban bus lines, by counting the crowd density of each bus station, a prediction model for the number and layout of the stations based on the crowd density is proposed, and the spatial layout of the stations is given. The problem of the number and layout of urban public bicycle stations has both development commonality and regional personality, and the crowd density model based on bus routes has universal value.

Chu Chang of Southwest Jiaotong University used the CITI BIKE public bicycle swiping data in New York City as a data set and used data mining methods to study the potential time-space and user travel characteristics of public bicycles. The two main influencing factors of weather and station type are integrated into the ARIMA model, to predict the customer trips of different types of stations separately and improve the accuracy of the prediction.

Domestically, a site demand forecast is mainly a static forecast of site planning and layout. Most researchers first calculate the total demand of the system and then allocate it according to the actual situation of the site. In foreign countries, there are many studies on the dynamic prediction of sites. According to the travel record data, after analyzing the user's travel behaviour characteristics using data mining, various prediction models are used to predict different time windows. However, due to the small number of influencing factors, the accuracy of prediction results cannot meet the requirements of system operation.

1.1. Current Status of Shared Bicycles

According to the "China Shared Bicycle Market Research Report" released by Bida Consulting, a third-party data research organization, the scale of China's shared bicycle market in 2018 was 10.8 billion yuan. In the first quarter of 2019, Trustdata data showed that the number of users of shared bicycles in China was about 40.5 million. From January to June 2019, the number of active users of independent APPs in the shared bicycle field fluctuated around 30 million. The scale of shared bicycles is getting larger and larger, which brings great convenience to users and also brings some problems.

(1) Tidal phenomenon, imbalance of supply and demand

For example, the number of stations in densely populated areas is not enough to meet the needs of residents to borrow and return cars; due to the phenomenon of traffic tides, there will be a two-way traffic imbalance in the morning and evening peak hours. Some sites have a large demand for rental cars in one direction while parking in the other direction. The demand is large, and some sites are in a vacant state, users cannot borrow a car, and some sites are full, and users cannot return the car;

(2) Lack of intelligent management of supply and demand

The number of vehicles demanded by the station mainly relies on manual experience to schedule fixed stations, lack of platform data support, and the level of intelligent management needs to be improved. At present, the demanding scheduling of shared bicycle users is mainly carried out through a combination of manual inspection and site video monitoring. This method has great shortcomings: First, the cost of manual inspection is high and the efficiency is low; the scale of shared bicycles is large and the coverage is wide, and it is difficult to schedule some fixed sites only by manual experience, which is difficult to solve the long-term lack of vehicles at other sites. The problem. Second, with the gradual increase in the number of outlets, video surveillance cannot understand the situation of each outlet in real-time.

To alleviate the problems of difficulty in borrowing and returning bicycles, improve user satisfaction, reduce manual inspection costs and system operating costs, and improve the intelligent service level of the shared bicycle system as a whole, a reasonable and accurate site demand forecast is necessary. This paper studies the travel characteristics of users in the system by using the travel data and site location information of the shared bicycle system.

Figure 1. Shared Bicycles in Wenzhou

2. Data Sources

The data used in this paper come from two sources. One part is based on the 20-day travel data of the shared bicycle system in Wenzhou in September 2018 as the original data, and a total of 10,763,245 travel records were obtained. Each trip record contains information such as vehicle number, vehicle number SN, start/end time, name of the lending/returning station, station number, card type, etc.

Another part of the data used comes from questionnaires. The survey was carried out in typical areas such as Wuma Street, Zhongshan Park, Xincheng District, Guanghua Bridge, and Nanpu Street in Lucheng District, Wenzhou City. The issuance time is a total of 9 days, which are October 14, 15, 21, 22, and October 23 to 27, including 5 working days and 4 non-working days. The questionnaires were distributed and collected face-to-face. The object of the survey is the resident residents of Lucheng District, who are divided into two categories of people who use shared bicycles and those who do not use them. Two types of questionnaires are designed specifically. A total of 347 valid questionnaires were recovered, including 205 for bike-sharing users and 142 for non-users.

This paper analyzes the 20-day travel data of shared bicycles at the above 180 sites and analyzes the system borrowing and returning characteristics, such as the characteristics of borrowing and returning time, frequency characteristics, turnover rate, etc. An in-depth understanding of the operation rules of the system; clarifying the influence of the main influencing factors on the system travel will help the operation management department to take effective measures to improve the service level of the shared bicycle system and the user's satisfaction with the system, and appropriately control the system operation and management The cost is of great significance to the sustainable development of the shared bicycle system.

3. Analysis of Travel Characteristics of Shared Bicycles

i. Age

According to the survey information, the users of shared bicycles are young people, and the ratio of males and females is half. People aged 25-35 use it the most, followed by people under the age of 25. The survey data shows that the awareness of shared bicycles and their use show an "inverted" trend. With the increase in age, the proportion of people who are aware of the "environmental protection and effectiveness" of shared bicycles is higher, and the highest proportion is 80.3% of people over 60 years old, and 59.7% of people under 30 years old; "In terms of awareness, the older you are, the higher the proportion of people who are aware of this problem, 39.3% of people over 60 years old, and only 21.6% of people under 30 years old. This also reflects that young people pay more attention to the meaning and value of shared bicycles, while middle-aged and elderly people pay more attention to the economic and social impacts of shared bicycles.

ii. Travel time distribution

The travel time of shared bicycles is multi-peak, with obvious morning and evening peaks. The morning rush hour is concentrated between 7:00-9:00, accounting for *% of the total travel volume of the whole day, mainly for commuting, with concentrated traffic and a single purpose of travel. The evening peak is concentrated in 17:00-19:00, and the travel volume accounts for 50% of the whole day. It can be seen from the figure that the morning and evening peaks lasted for 2 hours, and there were two small peaks at noon, accounting for 20% and 15% of all-day trips. According to the credit card data, the time distribution of people's use of shared bicycles is similar to the time distribution of the above outlets. The use time is concentrated on weekdays, with obvious peaks in the morning and evening, and the use intensity of the morning and evening peaks is about twice as high as usual. On the weekends, it is very flat, and the usage time is more concentrated than on weekdays. The morning peak is about 1 hour behind, and the evening peak is about 1 hour ahead.

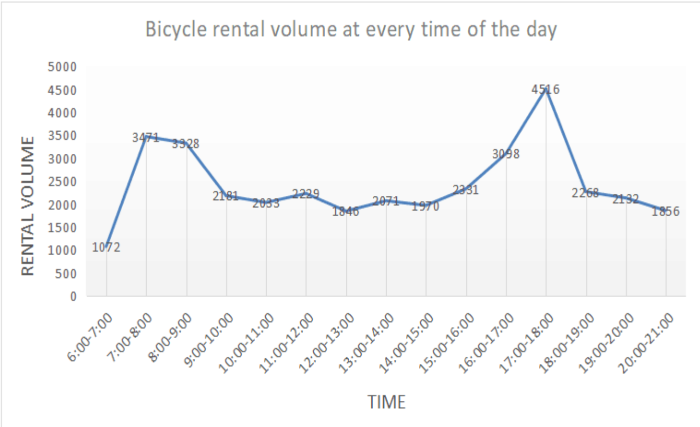

Figure 2. Example of Rental Volume a Day

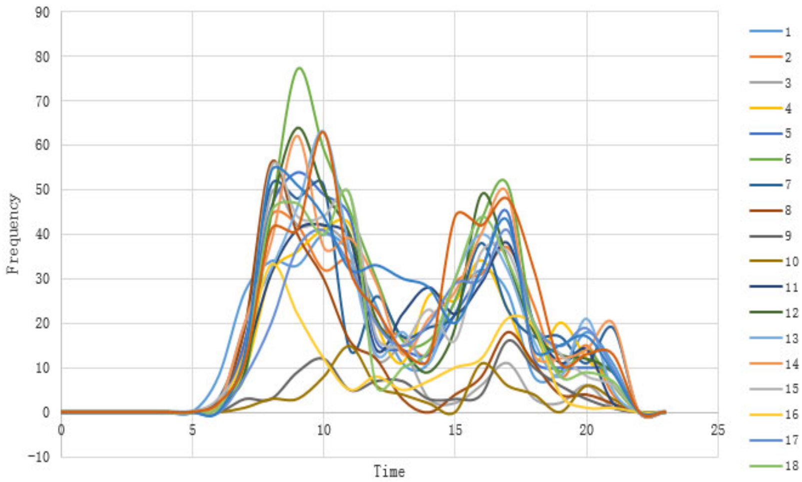

Figure 3. Example of Rental Volume a Day Lent Frequency

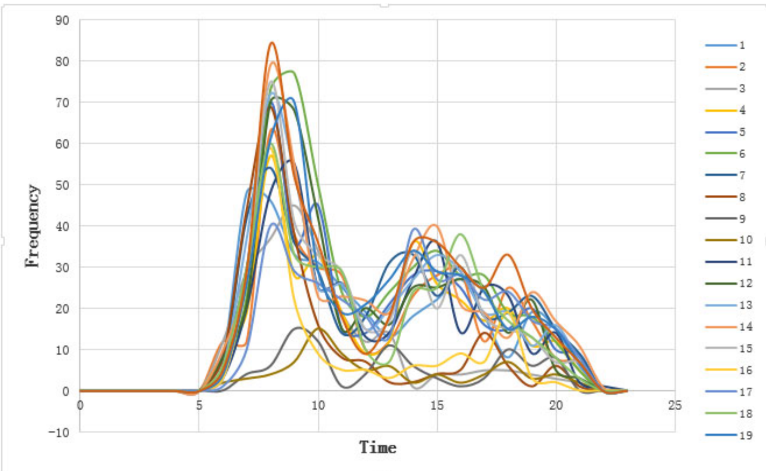

Figure 4. Restitution Frequency

iii. Mode of travel and purpose

There are three modes of travel using shared bicycles:

The first type of travel is “full mode”, that is, users use shared bicycles as the only travel tool, and about 78% of the trips are usually “home-bike-sharing-destination”. This method is generally used for short-distance travel within 3 kilometres. The main purpose is shopping, commuting and doing errands. It mainly replaces the residents' walking, short-distance public transportation, private bicycles and private cars. The average riding time is 12.8 minutes. The whole mode generally occurs in the area, sometimes directly to the destination, sometimes it is a multi-point continuous trip, and a short stay in the middle for shopping or doing business has a variety of purposes.

The second mode is the "transfer mode". Most users transfer between shared bicycles and buses, and 20% of the trips can be classified into this category, usually "home - shared bicycle - subway station/bus station - (shared bicycle). Bicycle) - Unit" mode. The average ride time in this mode was 10.9 minutes, with commutes accounting for 89 per cent.

The third mode is the "round trip mode". Users borrow and return shared bicycles at the same service point. Only 2% of trips belong to this type. Usually, the method of "starting point - shared bicycle - starting point" is adopted. There may be stops in the middle and no Fixed destination points and routes are non-utilitarian trips. The average ride time in this mode was 22.5 minutes.

iv. Travel distance and time

The travel distance of shared bicycles is mainly concentrated in 1-4km, accounting for more than 56%. The proportion of trips within 1km is 20%, and the proportion of trips above 7km is less than 10%. It can be seen that the advantages of shared bicycles are mainly reflected in short-distance travel within 1-4 kilometres.

More than 19% of shared bicycle trips took less than 10 minutes, and 63% of the trips took less than 20 minutes. The travel time of shared bicycles increased first and then decreased, with an average travel time of 16.15 minutes. After 30 minutes, the travel time shows a clear downward trend.

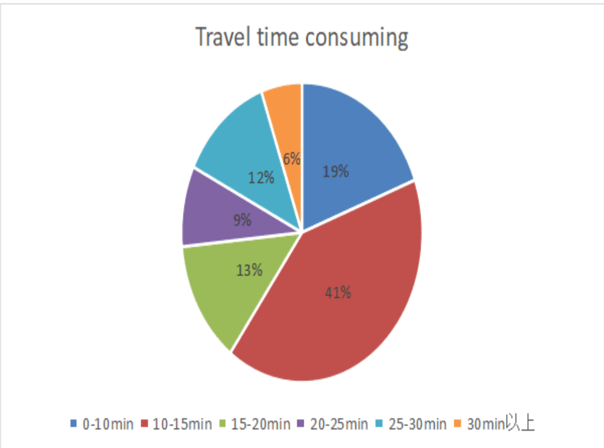

Figure 5. Travel time consuming

To sum up, shared bicycles have great advantages in short-distance travel. When the travel distance is 1~4km and the usage time is 15~30min, the probability of travellers choosing shared bicycles is high. When the travel distance is more than 4km and the travel time is more than 30min, due to the limitation of physical strength and travel efficiency, travellers are more inclined to choose motorized transportation.

v. Travel Mode

Through the analysis of the travel data of the above 180 stations, it is concluded that:

a. The 5 busiest sites

They are Street Park, Wuma Food Forest, Kaitai Department Store, Sports Center West, and Medical College.

b. The 5 most idle sites

They are Women and Children's Center, Wangjiang Road Guanghuaqiao Intersection, Lafite Resort Hotel, Sanqiaoxia and Times Seaview.

c.The number of people using shared bicycles is the largest on Tuesdays, and the number of people using shared bicycles is the least on Saturdays.

d.Each bicycle is used an average of 10.3 times a day, with the most bicycles being used 7 times a day.

e.For the same borrowing and returning stations, most of the stations have 10 to 20 borrowings per day. Most of the stations have an average ride time of 15-25 minutes.

vi. Network distribution

The bicycle-sharing outlets in Lucheng District are concentrated in the downtown area and nearby residential areas. Formally, several streets are used as a concentrated area, which spreads out to the surrounding areas. Judging from the type of land where the outlets are located, they are mainly distributed in residential land and commercial land. Small commercial streets and the surrounding areas of residential quarters are the most densely distributed locations. The number of vehicle piles in these outlets ranges from a dozen to dozens of vehicles. . Some industrial sites also have outlets, but the interval between them is relatively large. In addition, there are also branches near hospitals, schools, governments and other institutions.

vii. Car experience

The survey data showed that most citizens (62.1%) fully affirmed the convenience and environmental protection brought by shared bicycles, but 42.5% of the citizens were worried that some users would destroy or occupy them for themselves, and 29.3% of citizens think that "shared bicycles park illegally and disrupt the normal order"; in addition, 23.0% of the citizens are tasked with "increasing bicycles and occupying limited social resources", 20.7% of the citizens think "vicious competition among peers, reducing user experience", and 14.7% 6.9% of citizens think that "the development of bicycles is not enough and the number is insufficient", and another 6.9% of the citizens think that "it is inconvenient to find an idle bicycle when you want to use it".

4. Conclusion

Taking a bicycle-sharing system of a brand in Lucheng District, Wenzhou City as an example, this paper systematically examines the impact of the system on the travel of residents in Lucheng District since its implementation, to provide a reference for the development of shared bicycles in Wenzhou and my country. The research is based on the data samples of users' credit card data and the samples obtained from field questionnaires and are carried out from the aspects of network operation characteristics and residents' use characteristics.

In terms of operating characteristics of outlets, it is mainly found that the distribution of usage time of outlets of different land types is different: the outlets of traffic land, residential land and public land all have bimodal usage time distribution characteristics, among which the bimodal intensity of traffic land outlets The evening peak of residential and public land sites is slightly weaker than that of the morning peak; the use of commercial sites has only the morning peak and no evening peak. This can be used as a reference for the allocation of shared bicycles.

In terms of residents' travel characteristics, commuting and shopping are the main travel purposes for people to use shared bicycles. Due to the relatively rigid needs of these purposes, people use shared bicycles infrequently, on average twice a day. Therefore, the promotion of shared bicycle travel in the future can be placed on travel for leisure and exercise purposes, which requires cooperation in the improvement of the riding environment.

The distribution of people's usage time of outlets on weekdays also presents a bimodal pattern, with the morning and evening peak intensity being about twice as high as usual; however, there is no obvious peak usage on weekends. Correspondingly, there are also pendulum-like characteristics in time and space, especially the traffic land network. In the past, the main modes of transportation of shared bicycle users were walking, public transportation and private bicycles, and the number of conversion from cars were very small, and its low-carbon effect deserves further study. Convenience is the main reason why people use shared bicycles, far higher than the second time saving, and the actual time saving is not significant. People's use of shared bicycle modes can be divided into three types: full-course, transfer, and round-trip, with the full-course mode being the vast majority. Therefore, the development of shared bicycles should maintain and strengthen this advantage of flexibility and convenience, and promote people to use shared bicycles for multi-purpose travel through the overall planning of network layout and land use layout.

5. Development Proposals

Taking Wenzhou City as an example, this paper uses the shared bicycle credit card data as the main data support to discuss the travel characteristics of shared bicycles in coastal areas and municipalities, conduct multi-dimensional feature analysis and operation evaluation, and give operational scheduling suggestions.

Shared bicycles have entered the market based on the concept of green and low-carbon environmental protection. According to the investigation and research, the development of shared bicycles has reached a bottleneck period in recent years, which has also increased the difficulty of social and public governance. After the explosive growth, shared bicycles should find problems in time and commit themselves to more refined management and green development, to move towards maturity. To better promote the development of shared bicycle resource conservation and environment-friendly means of transportation and promote a sound "B2C" e-commerce model, we should pay attention to the problems of resource waste and ineffective allocation in the shared bicycle industry chain. Enterprises should implement the "3R" theory (Reduce, Reuse, Recycle) into the shared bicycle industry chain, implement self-regulation, improve green awareness, implement green behaviour, innovate green technology, and achieve green performance. The third-party platform implements cloud supervision based on technology.

The government should also carry out regulation and external supervision from a macro perspective. Promulgate relevant laws, carry out refined management and publicize green concepts. Both the sharing economy and the "B2C" model of e-commerce are the general trends of the future economy. Only by solving the green development problems of the shared bicycle industry chain and market launch can we set an example for other industries to truly realize the sharing economy and e-commerce. Sustainability and Transformation.

Government Green Governance Realizing the green development of shared bicycles requires proper government access. As a quasi-public product, shared bicycles need the government to effectively perform their responsibilities to complete market management when the market fails. The following points can be achieved. ① The government strengthens refined management, and the relevant departments are accurately positioned. They can share the data system with the third-party platform for shared bicycle management, cooperate with them, and master the first-hand data. At the same time, coordinate planning among departments such as the Ministry of Public Security and the Ministry of Transport to avoid overlapping powers, slow decision-making, long and cumbersome governance procedures and high costs. Reasonable planning of urban layout, strengthening of infrastructure, ensuring that there are stops in areas with high traffic flow, and rational allocation of existing resources, while avoiding the occupation of public road resources (blind roads, etc.). ② Improve relevant laws and regulations. For example, formulate corresponding standards and regulations for the discharge of pollutants recovered in the later stage of shared bicycles, specify the standards for platform vehicles and technical standards, and raise legal penalties for the malicious destruction of bicycles by the shared bicycle lessee. Create a macro external environment for the green development of shared bicycles.

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References

[1] Borgnat P , Fleury E , Robardet C , et al. Spatial analysis of dynamic movements of Vélo'v, Lyon's shared bicycle program[J]. complex systems society, 2009.

[2] Shen S , Wei Z Q , Sun L J , et al. The Shared Bicycle and Its Network—Internet of Shared Bicycle (IoSB): A Review and Survey[J]. Sensors, 2018, 18(8):2581-.

[3] Vogel P , Greiser T , Mattfeld D C . Understanding Bike-Sharing Systems using Data Mining: Exploring Activity Patterns[J]. Procedia - Social and Behavioral Sciences, 2011, 20(6):514-523.

[4] Lin Y , Liu J , Dou W . Analysis of Mobility Features of People Trip Based on Rental Station Data in Public Bicycle System.

[5] J.B. Griswold, Y. Mengqiao, F. Victoria, G. Offer, J.L. Walker, A behavioral modeling approach to bicycle level of service, Transportation Research Part A: Policy and Practice 116 (2018) 166-177.

[6] Z. Cen, J.D. Schmöcker, A Markovian model of user adaptation with case study of a shared bicycle scheme, Transportmetrica B (2) (2017) 1-14.

[7] S. Amini, S. Toms, Accessing capital markets: Aristocrats and new share issues in the British bicycle boom of the 1890s, Business History (5) (2018) 1-26.

[8] Neal, Lathia, Saniul, et al. Measuring the impact of opening the London shared bicycle scheme to casual users[J]. Transportation Research Part C Emerging Technologies, 2012.

[9] W.L. Al-Yaseen, Z.A. Othman, M.Z.A. Nazri, Multi-level hybrid support vector machine and extreme learning machine based on modified K-means for intrusion detection system, Expert Systems with Applications 67 (2017) 296-303.

[10] H. Liu, J. Wu, T. Liu, Spectral Ensemble Clustering via Weighted K-Means: Theoretical and Practical Evidence, IEEE Transactions on Knowledge & Data Engineering 29(5) (2017) 1129-1143.

[11] Zhang Y , Wan X , Zhang S . Analysis and Exploration of Open Source Data in Traffic Network Based on Scheduling Model of Bike-Sharing[J]. International Journal of Pattern Recognition and Artificial Intelligence, 2021.

[12] J.F. Tong, User clustering based on Canopy+K-means algorithm in cloud computing, Journal of Interdisciplinary Mathematics 20(6-7) (2017) 1489-1492.

[13] Li, Dai, Zhu, et al. Analysis of Spatial and Temporal Characteristics of Citizens' Mobility Based on E-Bike GPS Trajectory Data in Tengzhou City, China[J]. Sustainability, 2019, 11(18):5003. [9] N. Clarke, F. Li, S. Furnell, A novel privacy preserving user identification approach for network traffic, Computers & Security, 70 (2017) 335-350.

[14] X. Zhang, S. Mahadevan, A Bio-Inspired Approach to Traffic Network Equilibrium Assignment Problem, IEEE Transactions on Cybernetics 48(4) (2018) 1304-1315.

[15] Li, Dai, Zhu, et al. Analysis of Spatial and Temporal Characteristics of Citizens' Mobility Based on E-Bike GPS Trajectory Data in Tengzhou City, China[J]. Sustainability, 2019, 11(18):5003. [12] D. Wang, W.W. Che, H. Yu, Adaptive Pinning Synchronization of Complex Networks with Negative Weights and Its Application in Traffic Road Network, International Journal of Control Automation & Systems 16(2) (2018) 782-790.

[16] Qin K , Zhou Q , Wu T , et al. HOTSPOTS DETECTION FROM TRAJECTORY DATA BASED ON SPATIOTEMPORAL DATA FIELD CLUSTERING[J]. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2017, XLII-2/W7:1319-1325. [14] H. Wang, Q. Wang, W. Wang, Text Mining for Educational Literature on Big Data with Hadoop (2018) 166-170.

[17] Zheng Q , Zhao X , Jin M . Research on Urban Public Green Space Planning Based on Taxi Data: A Case Study on Three Districts of Shenzhen, China[J]. Sustainability, 2019, 11. [16] W. Wang, Y.Q. Xu, Empirical Study on Spatial Type and Functional Location of Logistics Parks in Hebei Province Based on Cluster Analysis, Value Engineering 37(34) (2018) 22-23.

[18] S.Y. Gao, N. Li, W. Zhang, Empirical Research on Regional Spatial Layout Optimization under the Perspective of Circle Economy, Science & Technology Progress and Policy 34(3) (2017) 31-36.

[19] Z. Wang, Y. Sun, Y. Zeng, Substitution effect or complementation effect for bicycle travel choice preference and other transportation availability: Evidence from US large-scale shared bicycle travel behaviour data, Journal of cleaner production, 194 (2018) 406-415.

[20] Y. Li, B. Shuai, Origin and destination forecasting on dockless shared bicycle in a hybrid deep-learning algorithms, Multimedia Tools and Applications (2018) 1-12.

[21] Lathia N , Ahmed S , Capra L . Measuring the impact of opening the London shared bicycle scheme to casual users[J]. Transportation Research Part C Emerging Technologies, 2012, 22(none):88-102.

[22] Sun Y , Liu B , Zhang L . Research on Construction and Management of Shared Bicycle Parking Facilities[C]// 2020 International Conference on Urban Engineering and Management Science (ICUEMS). 2020.

[23] Peng Z , Xiaoyu M A , H Jiao, et al. Research on Urban Micro Public Space Planning Method under the Guidance of Data:A Case Study of Wuchang District, Wuhan[J]. Modern Urban Research, 2018. [21] B. Rakel, Children's influence on dual residence arrangements: exploring decision-making practices, Children and Youth Services Review, 91(2018) 105-114.

[24] Gao L , Ji Y , Yan X , et al. Incentive measures to avoid the illegal parking of dockless shared bikes: the relationships among incentive forms, intensity and policy compliance. 2021.

[25] Faghih-Imani, Ahmadreza, An empirical analysis of bike sharing usage and rebalancing: Evidence from Barcelona and Seville, Transportation Research Part A: Policy and Practice 97(2017) 177-191.

[26] J.B. Griswold, Y. Mengqiao, F. Victoria, G. Offer, J.L. Walker, A behavioral modeling approach to bicycle level of service, Transportation Research Part A: Policy and Practice 116(2018) 166-177.

[27] Strauss, Jillian, L.F. Miranda-Moreno, Speed, travel time and delay for intersections and road segments in the Montreal network using cyclist Smartphone GPS data, Transportation Research Part D: Transport and Environment 57(2017) 155-171.

[28] Zhang Y , Zhou Y . Research on Incentive Choice of Public Order Based on a Survey of Shared Bicycle Parking[J]. IOP Conference Series Earth and Environmental Science, 2021, 769(3):032016.

[29] Maas S , Nikolaou P , Attard M , et al. Spatial and temporal analysis of shared bicycle use in Limassol, Cyprus[J]. Journal of Transport Geography, 2021, 93(3).

[30] J Zacharias, Meng S . Environmental correlates of dock-less shared bicycle trip origins and destinations[J]. Journal of Transport Geography, 2021, 92(2):103013.

[31] Zou J , Zhang Z , Li M S . Analysis of Main Factors on Evaluation and Selection of Wet Waste Disposal Modes: A Case Study of Universities in Shanghai, China. 2022.

[32] Y. Yan, Y. Tao, J. Xu, S. Ren, H. Lin, Visual analytics of bike-sharing data based on tensor factorization, Journal of Visualization 21(4) (2018) 1-15.

[33] [1] An L , Tsou M H , Spitzberg B H , et al. Latent trajectory models for space-time analysis: An application in deciphering spatial panel data[J]. Geographical Analysis, 2016, 48(3):314-336.