
Analysis of Mobility Features of People Trip Based on Rental Station Data in Public Bicycle System

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Abstract

The global emergence of public bicycle system in urban has recently received a lot of attention in the performance and modelling research community. A particularly important challenge is data collection, due to operation data of public bicycle system not opening to the public. This paper provides an analysis of trading card and trip path data based on operation data from the public bicycle system in Hangzhou. It is significant to detect use of different population, temporal and geographic mobility features and the influence factor of bicycle usage at rental stations of public bicycles system. After making a qualitative analysis of movements using bicycles in the city, people using public bicycles in city give priority to citizens. The main influence factors of bicycles usage are geographical environment, season and holidays.

Keywords

Public bicycle system, rental station, mobility features, influence factors

1. Introduction

Under the background of the sustainable development of low carbon, as a kind of green and healthy transportation, public bicycle systems are being focused in urban around the world [1]. The mass development of the worldwide, Hangzhou is the earliest one of cities in China introduced free public bicycle system [2]. Along with the scale of public bicycle systems increasing gradually, the prominent problem is that there is no the bicycle at station when people would like to lend a bike or parking space at station is full when people want to return a bike. It is affecting the management and service of public bicycle. In order to solve this problem, In addition to layout optimization rental stations of public bike [3], scheduling system is set up in the operation of public bicycle systems [4]. Before the layout optimization and scheduling, it is a necessary to understand the operation status of public bicycle in urban and the people travel characteristics.

Recently there are some data mining literatures. Froehlich et al [5] was the first to use clustering technology to determine the behavior pattern of Barcelona's Bicing system; Dali et al [6] put forward the way to use data mining to analysis the weather conditions, geographical location, trip time, and the current available number of bicycles at the rental station; Montoliu et al [7] use city circular flow model to explore number change trend of bicycles at rental station; Borgnat et al [8] proposal a statistical model of combining signal processing and data analysis and data mining through the study of space-time and individual characteristics; Sarkar et al [9] grab online data and exert the hierarchical clustering method to analysis the available number of public. However, the data information is not

complete, such as site' accurate location and the capacity of the site; Chen et al [10] infer people's travel path information through web online data of public bicycle system; Corcoran et al [11] discuss geographical position and the usage pattern of 38 public bike system in the global view. Because of the data involving the problem of the privacy of users and high professional and technical requirements, these problems make it more difficult to study. These studies rarely used real and a large number of operational data of public bicycle system, and targeted for a city to conduct a comprehensive analysis the operation conditions and mobility characteristics.

2. Population analysis

In this section we analysis card record data of public bicycle system in Hangzhou, because the different types of cards reflect the travel number of different people, we can understand travel situation of different people across a city.

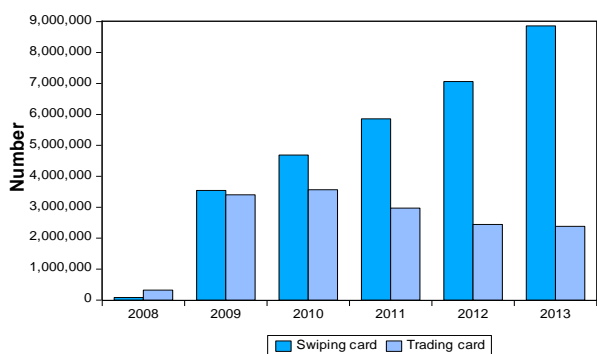


Fig.1 Number of trading card and swiping card

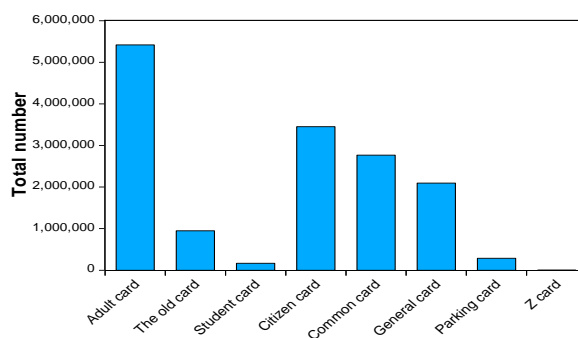


Fig.2 Travel number of different people

Fig. 1 shows the number of trading card and swiping card every year from 2008 to 2013. The number of trading decreased after increased first, achieving the most in 2009 and 2010. It suggests that public bicycle is accepted by people at starting stage. As time increases, the decrease reason of the number of handling card is that the number will reach saturated state, when it is limited in the quantity of urban population. Namely people in city of nearly have handled the rental card. Through comparing number of swiping card per year, we can learn to the use number of bicycle increases year by year. Fig. 2 shows the use number probability distribution of different types of people between December 2008 and January 2014. The use times of adults are much higher than the old and students. The student is the least one among them. The commuters usually are user of public bicycles. When the student chooses a way of travel, they rarely use the bicycles. We can discover that the use frequency of citizen card is highest, the second is common card and general card, and Z card (temporary card) is the least one. It shows that the use crowd of public bicycle in urban is given priority to the locals, then outsiders and tourists. The less use reason of visitors is that the cost handling card is too high, and formality is tedious.

3. Area analysis

In order to understand the operation situation of the public bicycle system on the macro, we analyze demand for the use of bicycles and the impact of seasonal changes. The main rental stations in Hangzhou, such as Jingqu, Jianggan, Shangcheng, Xiacheng, Gongshu and Xihu. Fig.3 shows demand change of six regions in 2013.

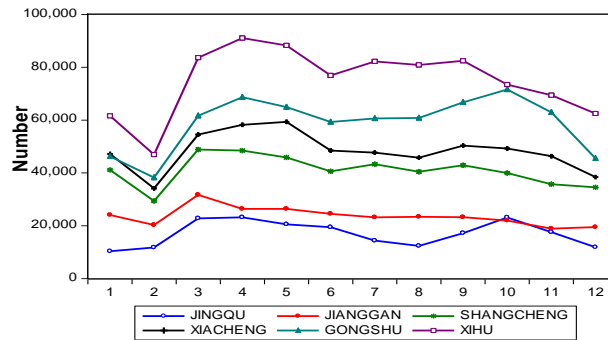


Fig.3 Demand number of six areas

In Fig.3, the demand of public bicycle at Xihu is largest, Jingqu and Jianggan is least. Since Xihu is a district owning the largest district and most population, one of five old cities in Hangzhou, which is a popular tourist area. However, commercial centers and tourist attractions in Jianggan are relatively less. This phenomenon can be explained that people's travel is greatly impacted by geographical features. According to geographical features, bicycle managers can add or delete the appropriate rental station, meeting the need of people's travel. In addition, we also can know the season affect usage of public bicycles from the Fig.3. The demand of public bicycle is higher in spring and autumn, declined slightly in summer, while the winter is minimum amount of the bike. This case illustrates the use of public bicycles is related to seasonal changes, the most obvious in winter. Since the spring and autumn temperatures is moderate and suitable for travel. It is hotter in summer. On the contrary, the winter is too cold. People generally choose other modes of travel.

4. Rental station analysis

Public bicycle systems are much affected by seasons, holidays and other factors for itself characteristics. Because of having analyzed the influence of the season in section 4, in this chapter, we will analyze the operation law of rental stations by three date type of samples, such as normal weekday, weekend and the national legal holidays. According to the similarity theory, each date type of samples represents the operation law for per week, and it fully reflects current operation situation of the public bicycle systems in Hangzhou. In addition, we select typical rental stations of the commercial, the residential, large bus stations, the scenic spot and hospital respectively are the Longxiangqiao, Cuiyuanyiqu, Gudang bus station, Shaoniangong, Wulinmen west.

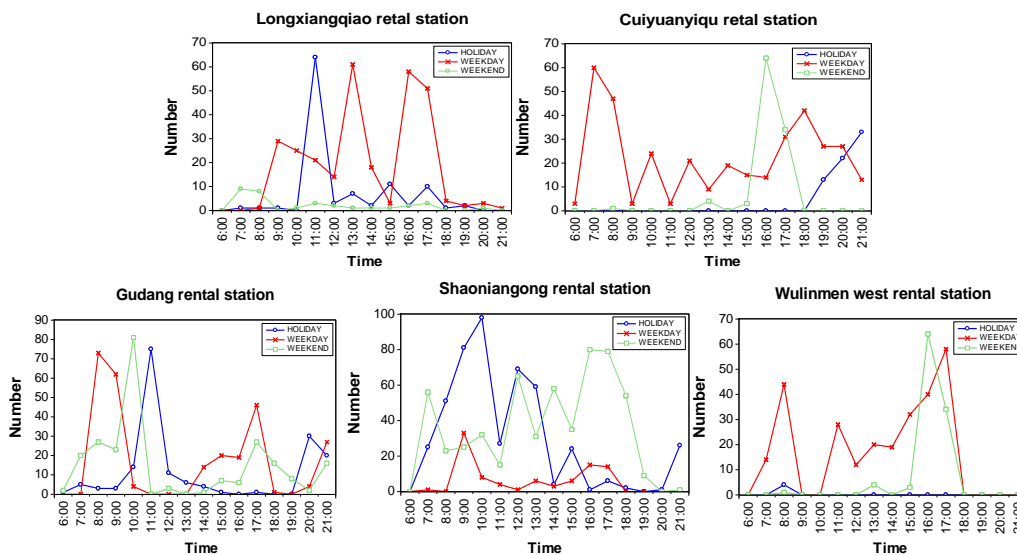


Fig.4 Demand number at different typical rental stations

Due to the space limitation, we only choose the analysis result of temporal characteristics for some typical rental stations. All kinds of the characteristic of rental stations are summarized. The Fig. 4 shows that in ordinary weekday, morning rush time is 8:30-10:30 at business center, residential area's is 6:30-8:30, and it is between 7:00-9:30 at central bus station, which indicates that people generally set out from the residential area in the morning, arrive at the bus station, and then work in the commercial center. Because of large population mobility in the commercial center, it is always in peak condition until 6:00 PM during the day. People began to disperse from the commercial center. During the holidays, peak time is from 10:30 to 11:30 in the commercial center, and the demand of bicycle is larger. However, residential areas appear the evening rush hour after 7:00, which indicates that, on the weekend, people go shopping in the morning, and at night they go back to residential areas. So morning rush in residential areas can be earlier than in the commercial center, evening peak in residential areas is later than in the commercial center, and the demand in the average working days is much higher than on weekends and holidays.

The bus central station on normal working days, weekends and holidays respectively appeared peak time at 7:30-9:30, 9:00-10:30 and 10:30-11:30. People's travel time on working day in the morning is earlier than on weekend, travel time is latest on holidays. When appearance order of evening peak in three types of date is in contrast to the morning rush time, it shows that people's travel time are different on different date. The total demand of bicycle in the central bus station is the same in three kinds of cases. At Gudang rental station the morning peak time on weekend is earlier on the holiday in the scenic spot, Working days' is the latest. On weekends and holidays, the demand of bicycle is much higher than on working days, suggesting that the demand is less in the scenic spot on working days. However it is much greater on weekends and holidays. Managers can arrange more vehicles in the scenic spot during weekends and holidays. At Wulinmen west rental station the demand of bicycle is larger on working days in the hospital, the morning peak at 7:00-8:30, the evening peak is between 15:00 to 17:30, suggesting that commuters usually use bicycles around the hospital station, Just at 15:00-17:30 it is heavy usage on weekend, but the use of bicycles is least during the holiday.

5. Conclusion

We show that the actual operational data about the public bike in urban, which allows us to infer a large city's population who usually used public bicycle as well as the factors that influence people's travel regularity in different rental stations. There are clear mobility features of user behavior by station and type of day. Visualization of the average daily variation in activity allows us to observe that stations with similar behavior also often correspond to adjacent areas in the residential, scenic spot and leisure areas. Weather conditions and many other factors (geographic characteristics etc.) need also be taken into account. The knowledge gained from analyzing the mobility features in Hangzhou could be very helpful in planning the future deployment of the public bicycle system throughout the city as well as identifying hotspots in the current infrastructure.

References

- [1] Parkes, S.D., Marsden, G., Shaheen, S.A., Cohen, A.P., 2013. Understanding the diffusion of public bikesharing systems: evidence from Europe and North America. *J. Transp. Geogr.* 31, 94–103.
- [2] Dijia Gong, Zhongdong Zhu. Implementation Mechanism of Urban Public Bicycle Systems. *Urban Transport of China Urban Transport of China*, 2008, 6 (6): 27-32.
- [3] J.-R. Lin and T.-H. Yang Ta-Hui, "Strategic design of public bicycle sharing systems with service level constraints," *Transportation Research Part E: Logistics and Transportation Review*, vol.47, no.2, pp.284–294, 2011.
- [4] Guner, AR, Murat, A. Dynamic routing under recurrent and non-recurrent congestion using real-time ITS information. *COMPUTERS & OPERATIONS RESEARCH*, 2011, 39(2): 358-373.

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- [5] Froehlich, J., Neumann, J., Oliver, N.: Sensing and predicting the pulse of the city through shared bicycling. In: Proceedings of the 21st International Joint Conference on Artificial Intelligence, pp. 1420–1426. Morgan Kaufmann Publishers Inc. (2009)
- [6] Dali Lorand, DMLadenic. BIKIKELJ: Environmental data mining on the bicycle//Information Technology Interfaces (ITI), Proceedings of the ITI 2012 34th International Conference on. IEEE, 2012: 331-336.
- [7] Montoliu R. Discovering mobility patterns on bicycle-based public transportation system by using probabilistic topic models//Ambient Intelligence-Software and Applications. Springer Berlin Heidelberg, 2012: 145-153.
- [8] Borgnat P, Abry P, Flandrin P, et al. Shared bicycles in a city: A signal processing and data analysis perspective. *Advances in Complex Systems*, 2011, 14(3): 415-438.
- [9] Advait Sarkar, Neal Lathia, Cecilia Mascolo. Comparing cities' cycling patterns using online shared bicycle maps. *Transportation*, 2015, 42:541-559.
- [10] Longbiao Chen, J é émie Jakubowicz. Inferring Bike Trip Patterns from Bike Sharing System Open Data. 2015 IEEE International Conference on Big Data.
- [11] Jonathan Corcoran, Tiebei Li, David Rohde, Elin Charles-Edwards, Derlie Mateo-Babiano. Spatio-temporal patterns of a Public Bicycle Sharing Program: the effect of weather and calendar events. *Journal of Transport Geography* 41 (2014) 292-305.

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