An Estimation of the Usage of Public Facilities Using Mobile Phone Data

Honglei Wang, Takehiro KASHIYAMA, Hiroshi OMATA, Yoshihide SEKIMOTO

Abstract： The population of Nanto city is declining year by year due to the sub-replacement fertility and the ageing of the population and the migration from small and medium-sized cities to metropolitan areas. Population decline has had a major impact on the social structure and economic development of the city of Nanto. The reduction of residents in Nanto leads to the idling of many communal facilities, as well as the reduction of local tax revenue and the increase of the operation and maintenance cost of public facilities. The decrease in the population has imposed a serious financial burden on the local government. To address the problem, the government of Nanto has proposed a plan to restructure public facilities in which officials prepared to sell underutilized facilities to the private sector for reducing public facilities. To effectively distinguish public facilities with different utilization rates, this paper will use mobile phone data to statistically analyze the frequency and number of visitors to public facilities by local residents, to help the government formulate a public facility restructuring plan.

Key words： Public facilities, Mobile phone data, The number of visitors, Efficient utilization

1. Introduction

The growth of the application of Mobile phone data in urban planning is now expanding and becoming part of the decision-making process for local governments.

In recent years, mobile data has been used to identify residents' commuting and further define the city's functional area (Doyle et al., 2014). Some scholars used relational signatures of activity time, duration and location in the data to discover activity patterns of residents. They developed a new technique to avoid compromising the accuracy of research by inaccurate phone trace information (Widhalm et al., 2015). Lwin and Murayama (2009) proposed a GIS using method based on Areametric and Volumetric methods and developed a tool named PopShape GIS to generate population attribute information. This method allows researchers to estimate the building population visually, spatially and statistically. Some researchers developed a web-based urban planning communication tool using open government data for enhanced citizen–government cooperation (Hasegawa et al., 2018).

At present, the urbanization process in Japan has gradually entered a period of stagnation. Due to the aggravation of the ageing problem and sub-replacement fertility, the spatial structure of cities and residents' life have undergone great changes. At the same time, the decrease in the number of urban population to the city of the daily operation management work has brought great pressure and challenge and it also produced a series of social problems.

The study area is Nanto city，which located in the

Honglei Wang 〒153-8505 4-6-1 KOMABA MEGURO-KU, TOKYO 153-8505, JAPAN

Department of Civil Engineering, the University of Tokyo

E-mail: whl1593@iis.u-tokyo.ac.jp

southwestern Toyama Prefecture, Japan. The population of Nanto city continued to decrease from the peak of 81000 in 1950. A lot of public facilities are idle, as well as the reduction of local tax revenue and the increase of the operation and maintenance cost of public facilities. Nanto city has a major development a public facilities restructuring plan, to reduce the negative impact of population decline.

Since the number of visitors to some public facilities cannot be counted (especially for the facilities in open area), this paper uses mobile phone data to estimate the number of visitors of each public facility in Nanto city. This paper divides the collected public facilities into eight categories. The estimation result reflects the use of each public facility within one month，provides a basis for government decision-making.

The rest of this paper is organized as follows. The analysis methodology is introduced in Section 2. In Section 3, we present the results and analysis. Section 4 concludes.

2. Methodology

2.1 Dataset Description

This study uses GPS data with National census data and public facility data. This GPS data is from a mobile phone company, which be regarded as one basic information for mobile phone application with the subscribers' permission. The GPS data includes user's location, trajectory, activity, period etc. each day. The table shows the list of data set, related information and the purpose of its use.

2.2 Data Processing

In this research, we calculate the number of visitors in each facility based on GPS data and the magnification factor. First, we used one-month nationwide mobile phone GPS data (2013.7.1-2013.7.31) to extract users in Nanto city. Since we want to the users who stay in target area, we only extract the data which activity mode is 'STAY'. Later, these data were matched to their home location, to compute magnification factors. Finally, we used these data to generate visitors for each facility by aggregating the total number of users with their magnification factors. The range of each facility area is 500m, this value can cover most of the facility's area.

Table 1. List of dataset, attribute information, and purposes.

Dataset name	Date	Attribute Information	Purpose
GPS data	2013.7.1-2013.7.31	User ID, Date, Activity, Longitude, Latitude	To extract users who are visit target area
Public Facility Data	2018	Facility name, Longitude, Latitude, etc.	To determine access range
National Census Data	2015	Demographic data	To compute home-based magnification factor

3. Result and Analysis

The final goal of this research is to get the frequency and number of visitors to public facilities (Figure 1, Figure 2). Figure 1 gives an example of the result of the visitor number in each day, the result shows this facility has low utilization, there is no visitor in this facility for a half month time. Figure 2 is the visualization of the average visitor number each day. The size of each buffer means the visitor number size. If the visitor number is large, the buffer is large. The highly utilized facilities are concentrated in urban areas since the large urban population. However, the usage of the facility is not mainly decided by the urban or rural area. From Figure3, which reflects the visitor difference in one of the concentrated areas, there are some facilities which have a small visitor number, these kinds of facilities

should be considered in the government restructuring plan.

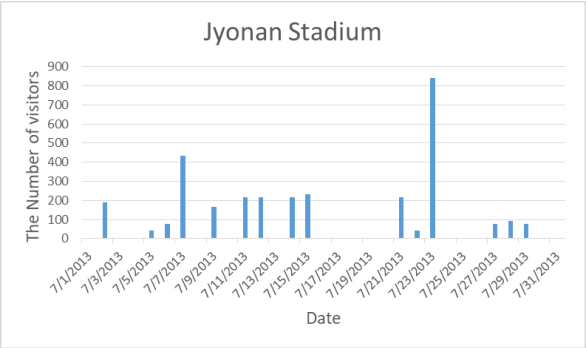


Figure 1. An example of the result of the visitor number

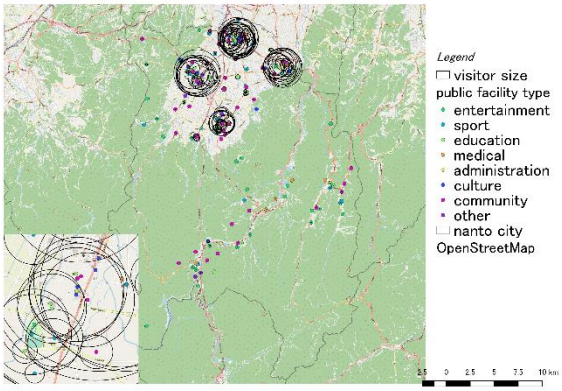


Figure 2. The location of public facilities and their visitor size

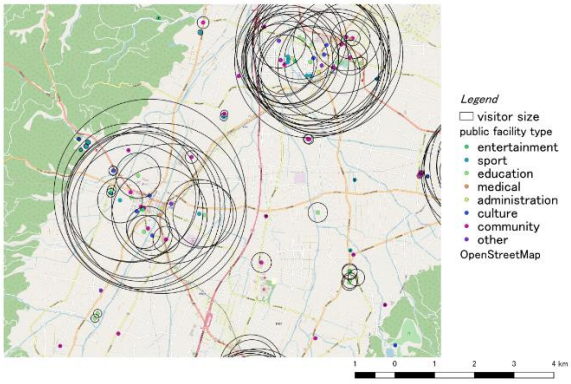


Figure 3. Different visitor size of public facilities located in the urban area

Figure 4 further illustrates that the distance between the user's home and public facilities does not have significant impacts on the number of visitors. Even if the facility is close to the user's home, the number of visitors is not necessarily high.

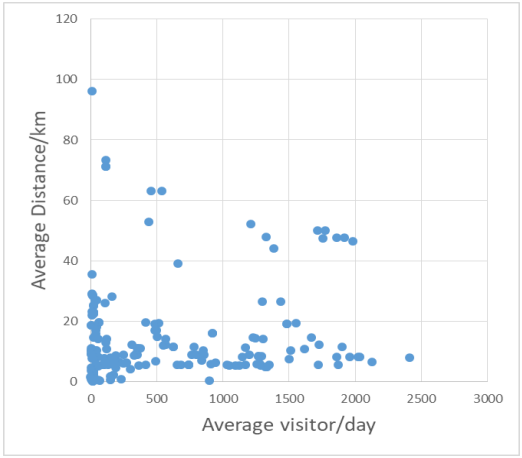
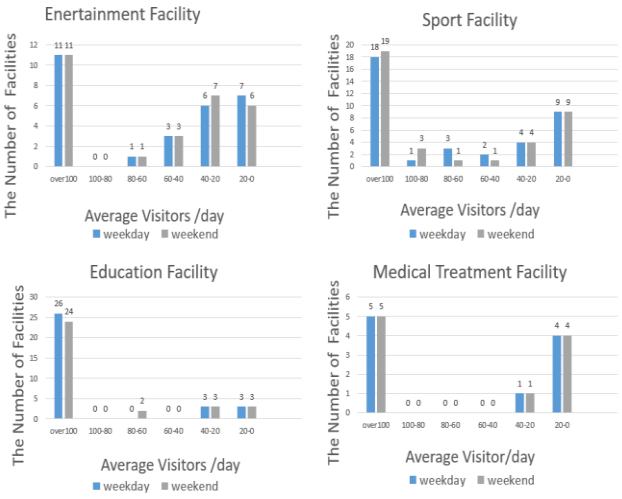


Figure 4.The relationship between the user's home location and the visitor of 188 public facilities

Figure 5 shows the average number of visitors to different types of facilities on weekday and weekend. From this result, we can see that the types of facilities with a daily average of visitors less than 20 are entertainment facilities, sports facilities and community facilities. It is proposed to change some of the public facilities for other purposes. Charts of cultural and administrative facilities suggest that these two types of public facilities may be operating at full capacity and that additional public facilities are needed to meet the mission requirements.



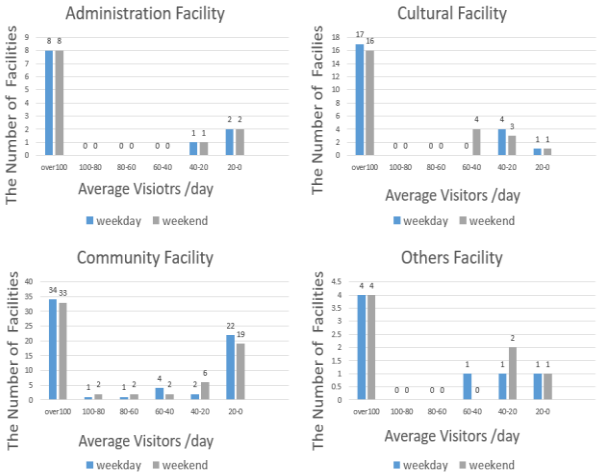


Figure 5. The average number of visitors in different types of facilities

To further identify whether the public facilities should be reduced or not, we visualize the service area of each facility. Figure 6 shows the distribution of some community public facilities and their service areas. The average daily number of visitors to these facilities is less than 20. The buffer means the service area of the community facilities. The service area is the average distance between the user's home and facility. Each facility has different service range and its service area has overlapping part with others, the overlapping parts indicate that the government has repeatedly set many facilities with the same functions. This result further proves that this kind of public facilities number needs to decrease.

4. Conclusion

Our research grasps and analyzes the status of citizens' use of public facilities, tries to determine the utilization status of public facilities based on mobile phone data, especially for the facilities in the open area.

However, because of the low population density in a rural area, the density of GPS data is also lower than in an urban area, this causes null data in some facilities.

For the future work, we want to compare this result with the result based other type of mobile phone data, such as CDR data, to provide a scientific theoretical basis for the planning and development of the modern city.

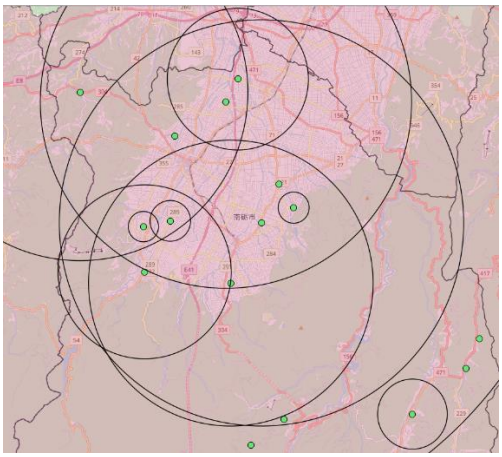


Figure 6. The service areas of community facilities (visitor number under 20) are overlapping

Reference

Doyle, J., Hung, P., Farrell, R., & McLoone, S. 2014, "Population mobility dynamics estimated from mobile telephony data", *Journal of Urban Technology*, 21(2), 109-132.

Widhalm, P., Yang, Y., Ulm, M., Athavale, S. & Gonzá lez, M.C. 2015, "Discovering urban activity patterns in cell phone data", *Transportation*, vol. 42, no. 4, pp. 597-623.

Lwin, K. & Murayama, Y. 2009, "A GIS Approach to Estimation of Building Population for Micro-spatial Analysis", *Transactions in GIS*, vol. 13, no. 4, pp. 401-414.

Hasegawa, Y., Sekimoto, Y., Seto, T., Fukushima, Y., & Maeda, M. 2018, "My City Forecast: Urban planning communication tool for citizen with national open data", *Comput. Environ. Urban Syst*.